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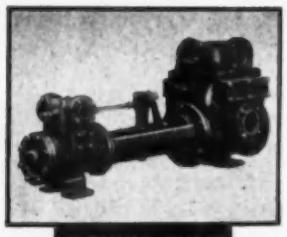

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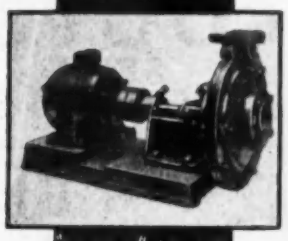

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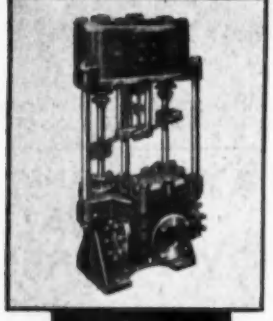

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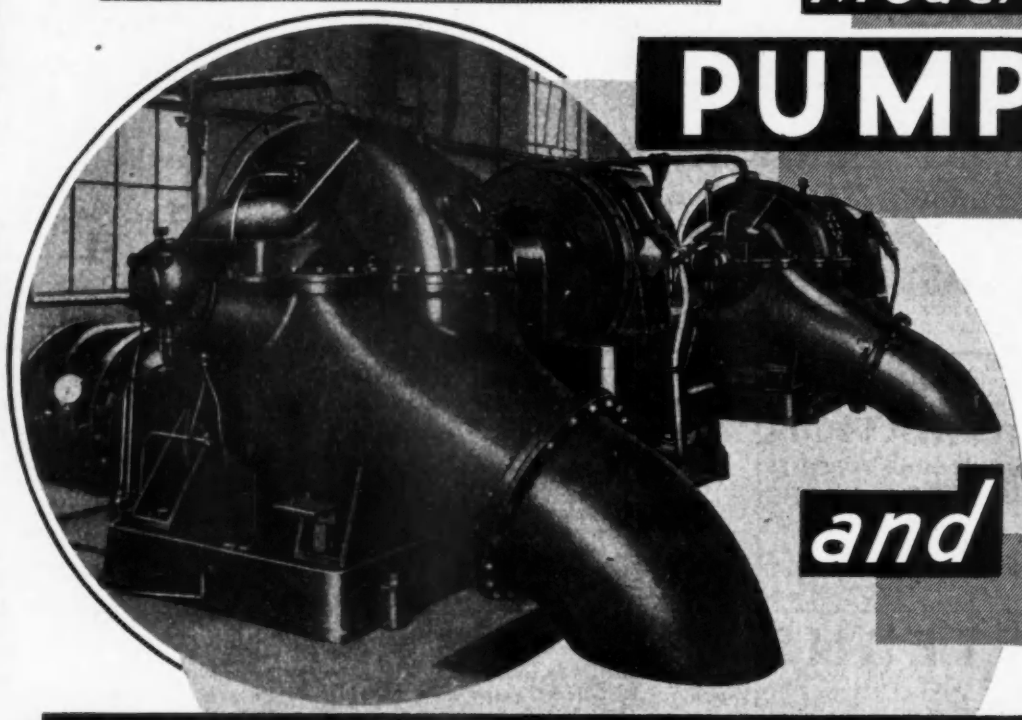

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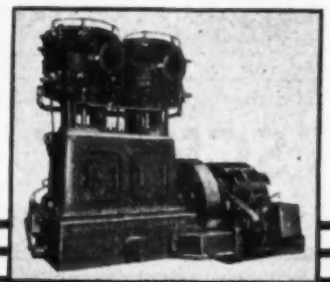

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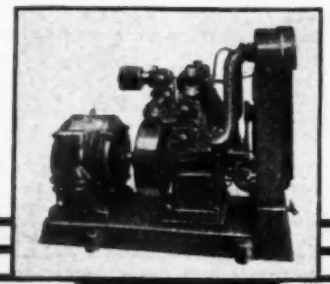

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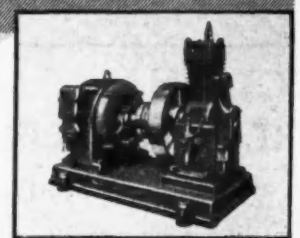

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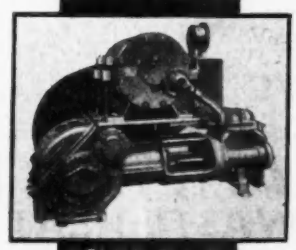

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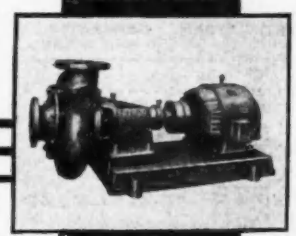

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INVESTIGATIONS ON INTERNAL-COMBUSTION ENGINES.

(*For description see page* 297.)

Fig. 69.

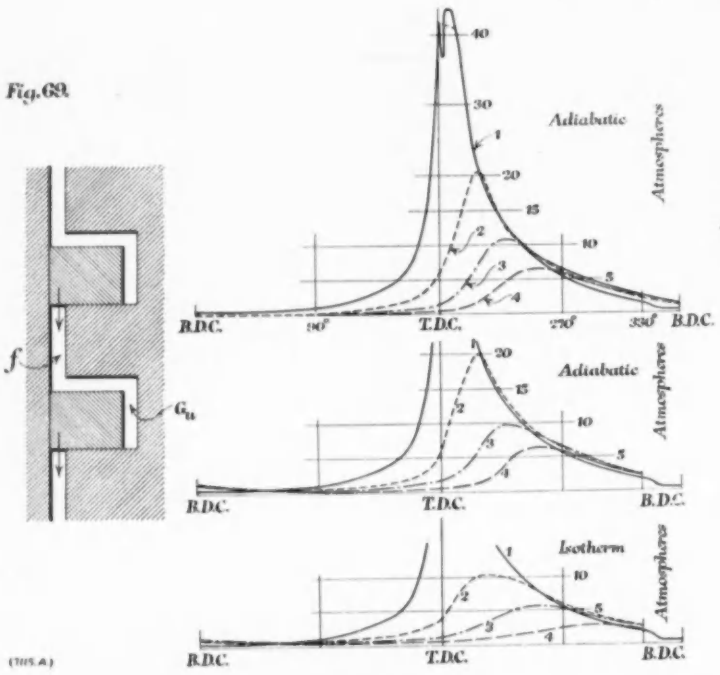
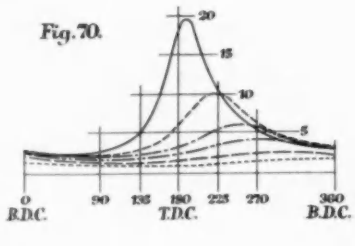


Fig. 70.



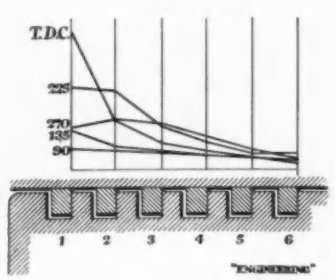


Fig. 71.

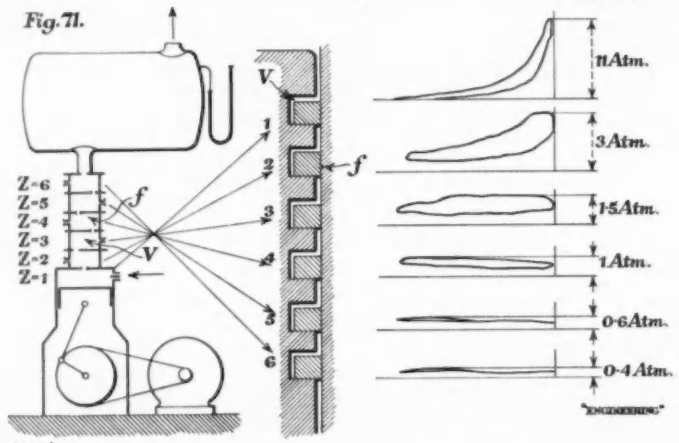
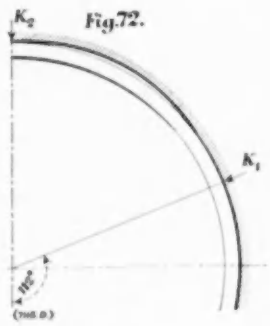


Fig. 72.



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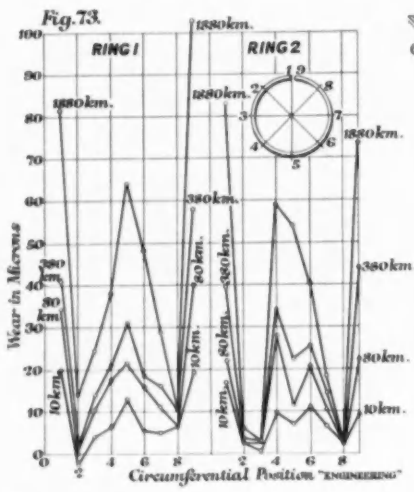


Fig. 76a.

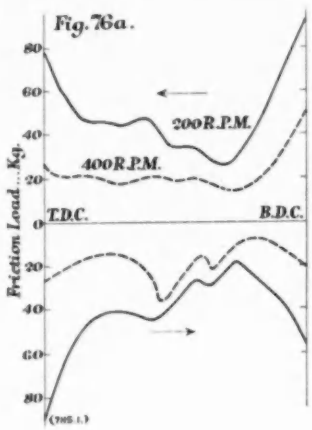


Fig. 76b.

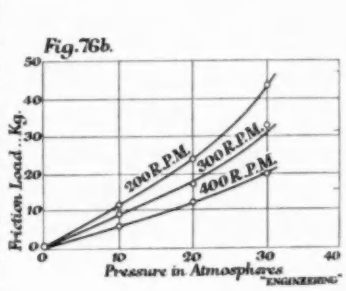


Fig. 74.

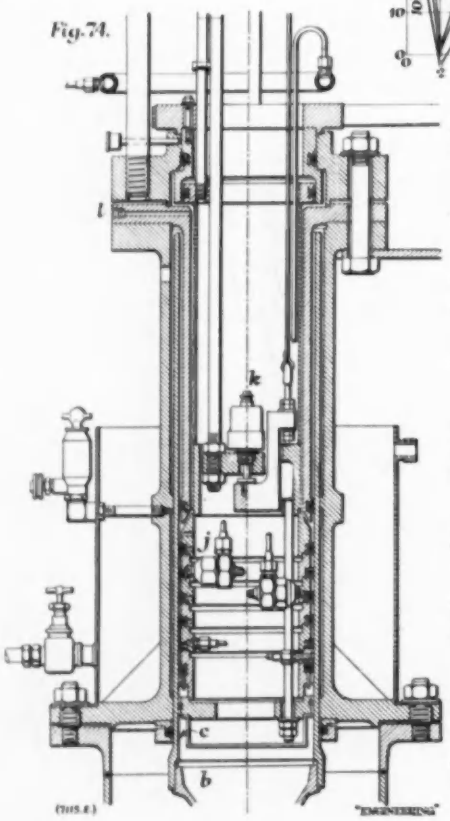
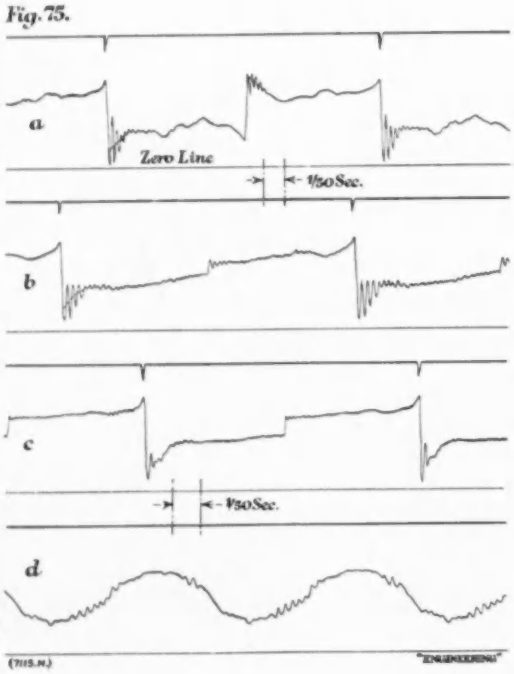


Fig. 75.



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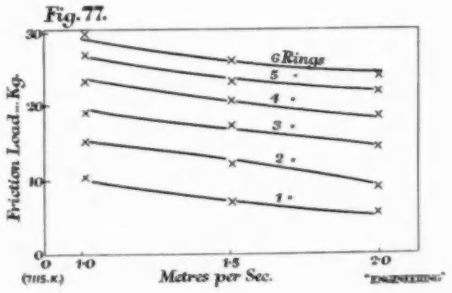
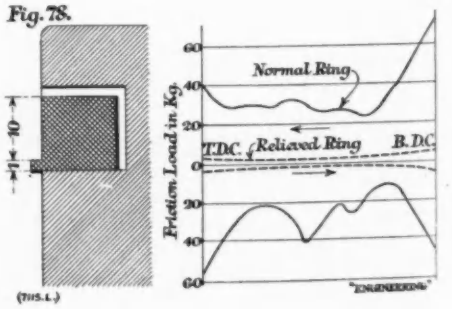


Fig. 78.



(*Between pages* 296 *and* 297.)

INVESTIGATIONS ON INTERNAL-COMBUSTION ENGINES.

(*For description see page* 297.)

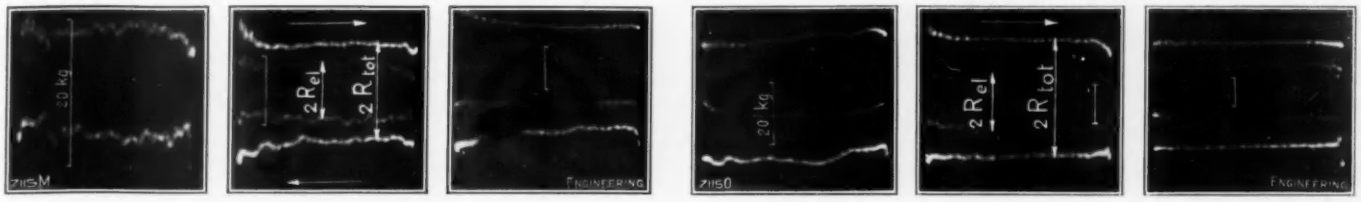


Fig. 79. *a* *b* *c*

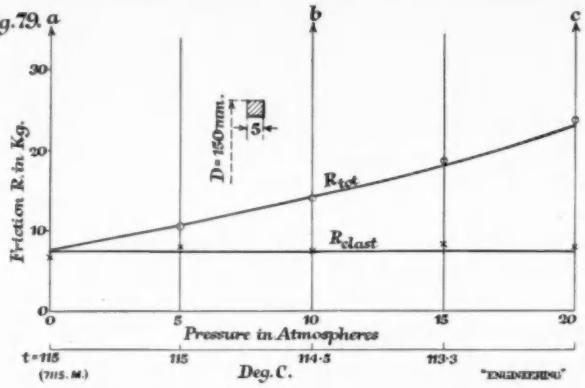
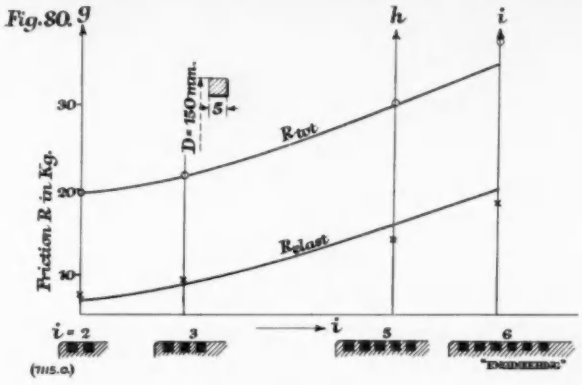


Fig. 80. *g* *h* *i*



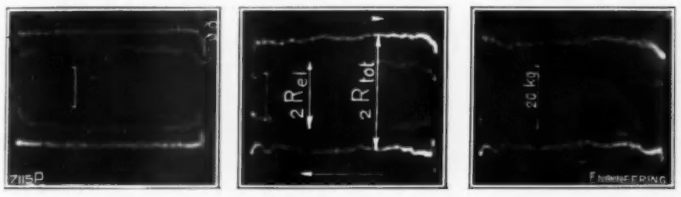
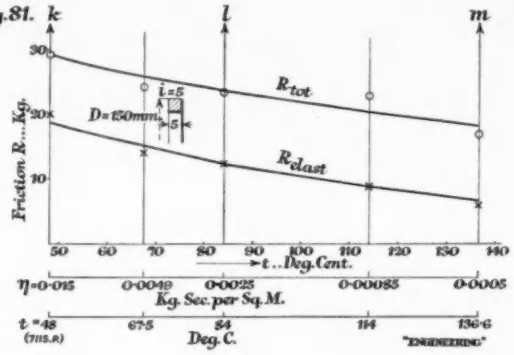
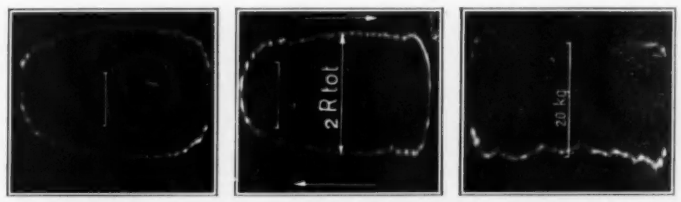


Fig. 81. *k* *l* *m*





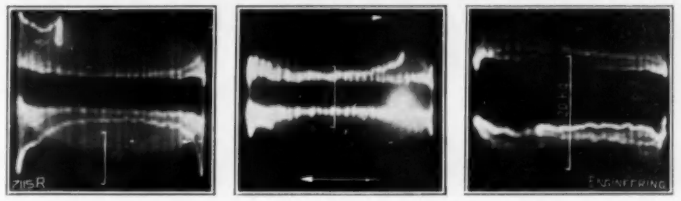


Fig. 82. *n* *o* *P*

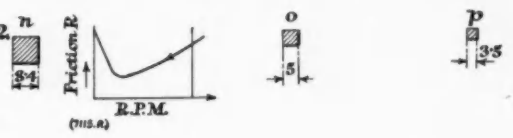
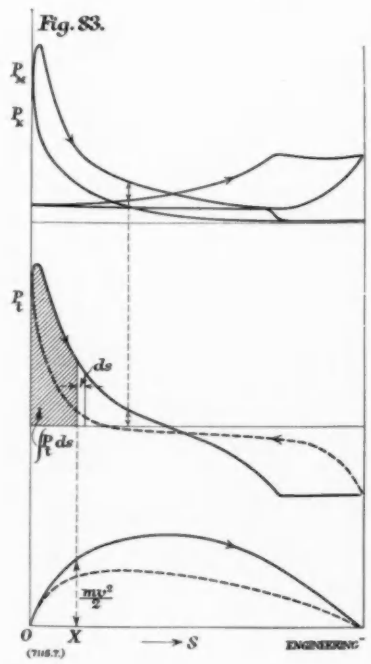


Fig. 83.



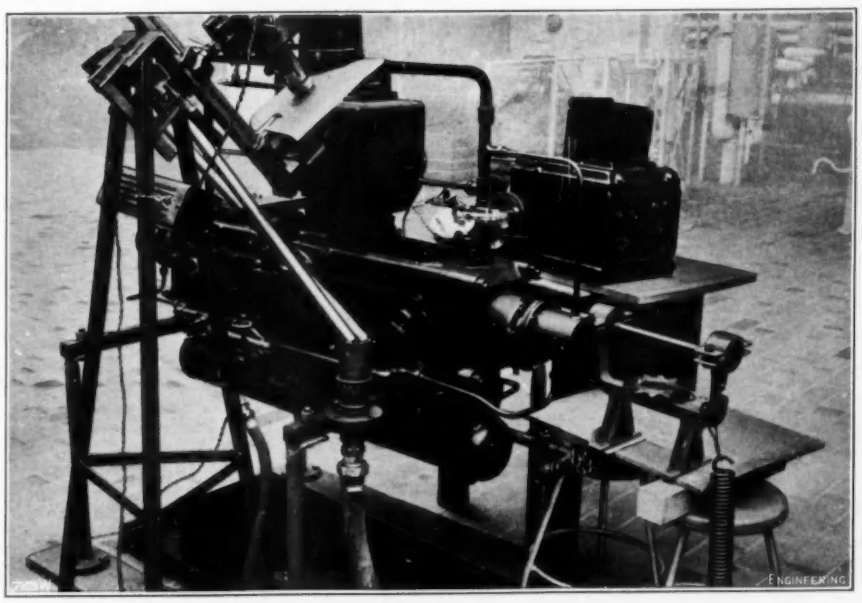


FIG. 84.

(*Between pages* 296 *and* 297.)

UNIV. OF MICH.

SOME NEW INVESTIGATIONS ON OLD COMBUSTION ENGINE PROBLEMS.—V.*

By PROFESSOR DR.-ING. G. EICHELBERG.

PISTON-RING PROBLEMS.

IN this last lecture, I wish, before I speak of new combustion-engine developments in connection with the investigations already discussed, to tell you some of the results of investigations on a small but important element—the piston ring. In this connection, something has already been said of the temperature and heat-flow conditions, but there remain the important questions of blow-by and of piston-ring friction.

20. *The Blow-By of Tight Piston Rings.*—With piston rings that are tight, gas leakage will occur only through the ring slots. The section of the passage is given by the tangential distance between the ring ends multiplied by the radial clearance between the piston and liner, in running condition. A sequence of piston rings forms a labyrinth, and if we had a constant cylinder pressure it would be easy to calculate the gas loss and the pressure distribution behind the rings. For example, for six rings and a constant pressure of 20 atmospheres in the cylinder, the pressure would drop to 12 atmospheres behind the sixth ring and through the last passage the gas would pass at the velocity of sound. Thus, the last ring would have the highest pressure drop and therefore also the greatest wear. As, however, the cylinder pressure in combustion engines varies periodically, there will be a periodic pressure fluctuation behind the rings, and the calculation will not be so simple.

Let us consider a two-stroke engine with four piston rings, running at 100 r.p.m. The ring groove clearance on the upper side of the first ring will always allow an instantaneous pressure balance between the cylinder and the space behind the ring. The pressure cycle behind the first piston ring will, therefore, be the same as in the cylinder. To calculate the pressure fluctuations,* we may consider that a gas weight $d\,G_1$ passes through the first passage f, as shown in Fig. 69, Plate XV. The balance of weight requires that the gas quantity G behind the second ring will increase by the difference of the income $d\,G_1$ and the loss $d\,G_2$, so that

$$d\,G = d\,G_1 - d\,G_2.$$

The energy $G\,u$ of the gas behind the ring will increase as :—

$$d\,(G\,u) = d\,G_1\,i_1 - d\,G_2\,i_2 + d\,Q$$

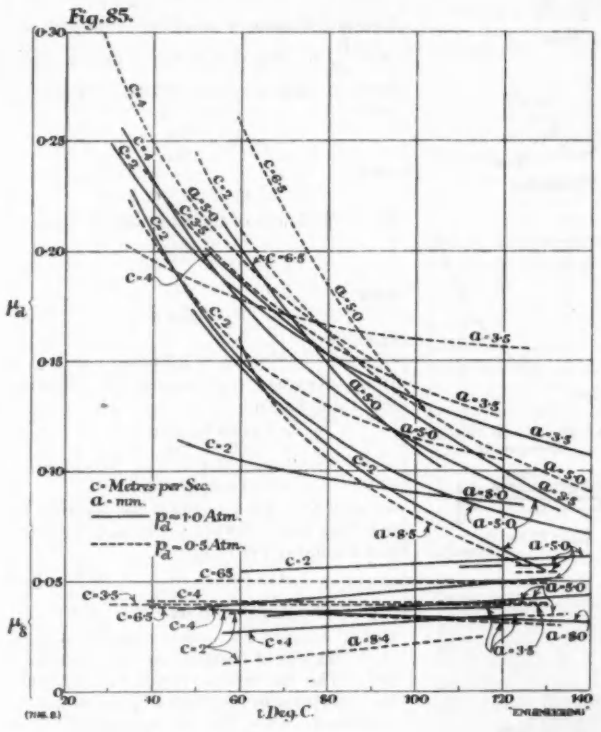
where i_1 and i_2 are the specific heat contents of the incoming and outgoing gas, and $d\,Q$ the heat supplied from the walls. The exact value of $d\,Q$ is difficult to establish, but it lies somewhere between zero (adiabatic process) and the value corresponding to full temperature balance between the gas and the walls (isothermal process). The first two diagrams in Fig. 69 are a first and second approximation calculated for the adiabatic process; the third is calculated for an isothermal process. The real pressure diagrams will lie somewhere between. We measured the pressure diagrams behind the rings in various model tests. The results for six rings and a two-stroke compression diagram (maximum pressure 20 atmospheres, mean piston speed 2 m. per second) are given in Fig. 70, Plate XV.

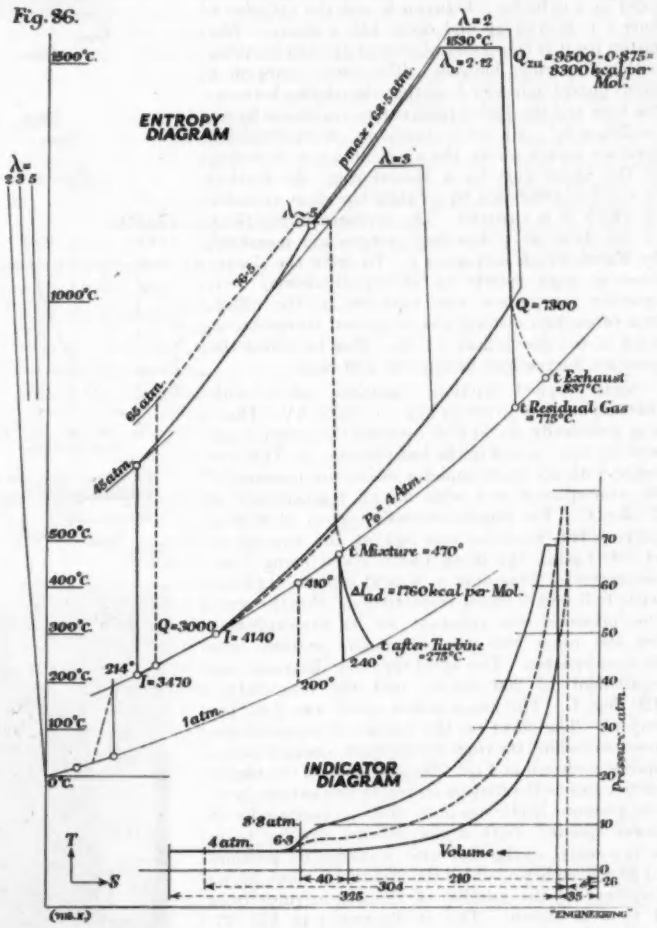
A simple model test is illustrated in Fig. 71. As the pressure diagram of an electrically-driven compressor is comparable with that of a two-stroke engine, different volumes V with passages f are arranged above the air cylinder, with different ratios of $\frac{V}{f}$. The diagrams of Fig. 71 are taken at 430 r.p.m. (2 m. per second mean piston speed) and $\frac{V}{f} = 22{,}700$ in millimetres, which is a good mean value for pistons. We tried by these tests to find a formula for the gas loss depending, if possible, only on the pressure diagram in the cylinder and not on the diagrams behind each piston ring. We found that the following formula for labyrinths with a constant initial pressure p_1,

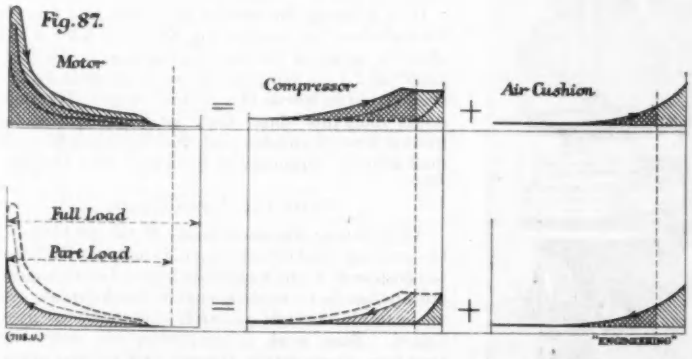
$$G_{sec} = \mu f \sqrt{\frac{g}{z + 1{\cdot}5}} \left(\sqrt{\frac{p_1}{v_1}}\right)_{mean}$$

holds good if for $\left(\sqrt{\frac{p_1}{v_1}}\right)_{mean}$ we use the mean value over time of the square root of the pressure over volume ratios in the cylinder during the cycle; the coefficient μ must be taken as 0·7.

If the ring is not tight the gas loss will, of course, be greatly increased. This may happen even if the ring is perfectly circular in a circular cylinder, when the engine gets hot. The calculation of the temperature deformations of the first ring in our four-stroke engine* showed that when the hot ring is in the cold lower part of the liner, only the ends of the ring will touch the liner with a pressure K_2, whereas about the first 60 deg. of the circumference will not touch at all and the maximum clearance may amount to some hundredths of a millimetre







* Fifth of a series of five lectures delivered before the University of London, at the Institution of Civil Engineers, on February 6, 1939, by Professor Dr.-Ing. G. Eichelberg, Professor of Mechanical Engineering in the Swiss Federal Institute of Technology, Zürich. The previous article appeared in our issue of Dec. 22, 1939, on page 682.

* M. Eweis, Reibungs und Undichtheitsverluste an Kolbenringen. Diss. E.T.H., Zürich, 1935. *Forschungsheft V.D.I.* Nr. 371.

* Fr. Salzmann. Wärmefluss durch Kolben und Kolbenring. Diss. E.T.H., Zürich, 1932.

(Fig. 72). This result explains the fact that piston rings often will not bear well at some distance from the open ends. This fact is shown, for example, in a publication of the Zeitschrift Forschung, 1935, reproduced in Fig. 73, which shows the wear at various points of two rings of a motor-vehicle engine cylinder after the vehicle had run various distances in kilometres, as indicated in the figure.

21. *The Friction of Piston Rings.*—It is more difficult to measure the friction of piston rings. To do this we built two testing machines. The first was suitable only for low piston speeds, up to 2 m. per second; the second, shown in Fig. 74, Plate XV, allows for piston speeds up to 8·5 m. per second. As will be seen, a stationary piston is fixed in a cylinder; between it and the cylinder a liner *c* is moved up and down like a sleeve. The piston itself is composed of several annular sections with piston rings between. The piston bears on a piezo-quartz indicator *k*, so that the friction between the liner and the piston rings can be registered by an oscillograph. Air at a constant, or fluctuating, pressure enters above the rings at *l* and is sealed in the upper part by a special ring, the friction of which is elminated by rotating the short cylinder in which it is situated. The pressure fluctuations in the different piston-ring grooves are measured by Farnborough indicators *j*. To drive the sleeve-liner at high speeds an electrically-driven two-cylinder compressor was installed in the cellar. One of its two pistons was connected to the cross-head of the sleeve liner *b*; the other furnished the pressure fluctuations behind the first ring.

Some typical friction diagrams taken with this machine are given in Fig. 75, Plate XV. There was practically no oil film between the piston rings and the liner except in the last diagram, *d*. This was taken with six rings, under a maximum pressure of 30 atmospheres and with an oil temperature of 70 deg. C. The diagram shows a typical oil-friction curve. The machine was run at the equivalent of 400 r.p.m., the mean piston speed being 2 m. per second. Diagrams *a*, *b*, and *c* were obtained with 1, 3 and 5 rings, respectively. For the first, the pressure was constant at 30 atmospheres; for the other two the maximum pressure was 30 atmospheres. The speed for these diagrams was equivalent to 200 r.p.m., and the temperature 120 deg. C. The mean piston speed was 1 m. per second. The effect on the friction of constant gas pressure behind the rings for different constant piston speeds is shown in Figs. 76*a* and 76*b*. At the higher piston speeds the friction increases proportionally to the pressure, and even more than proportionally at lower speeds. With a gas pressure varying as in a two-stroke cycle, and with a maximum pressure of 30 atmospheres behind the first ring, a diminishing influence of the number of the piston rings from 1 to 6 is shown. This is illustrated in Fig. 77. It is evident that smaller rings will have less friction. Fig. 78 shows friction diagrams of a normal piston ring and of a piston ring with a reduced bearing surface, as indicated in the sketch on the left. With this form the pressures behind and in front of the ring are balanced for the first 10 mm. of its depth. As shown by the dotted curves, smaller rings give less friction, but they also carry off less heat from the piston.

In the course of 1938, we carried out tests with the larger machine at piston speeds up to 8·5 m. per second and obtained over 1,000 friction diagrams. We have not yet had time to analyse all the material in detail, but full results will be published shortly.* On the basis of some series of diagrams, the general results may be briefly discussed at this stage. The first series, given in Fig. 79, Plate XVI, show the influence of a constant gas pressure in front of the first ring. The fainter inner lines in the photographic diagrams *b* and *c*, represent the friction during the upward and downward movements due only to the elasticity of the ring. The heavier outer lines in diagrams *a*, *b*, and *c* represent the total friction. The diagrams refer to the machine when fitted with four rings, each 5 mm. thick. The mean piston speed was 2 m. a second. With a temperature between the ring and liner of 120 deg. C. we reached semi-fluid friction. The "elastic" friction is practically constant and varies only with a variation of the temperature, *i.e.*, of the viscosity. The "additional" friction increases approximately in proportion to the pressure.

The influence of the number of piston rings is shown in Fig. 80. The "elastic" friction increases

Fig. 88.

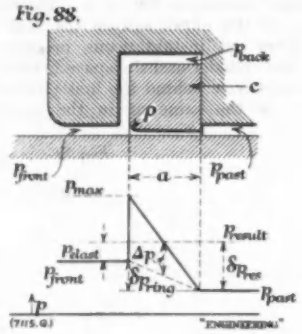
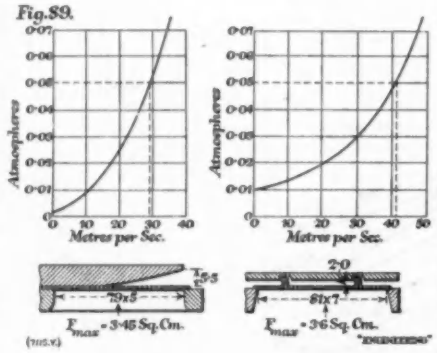


Fig. 89.



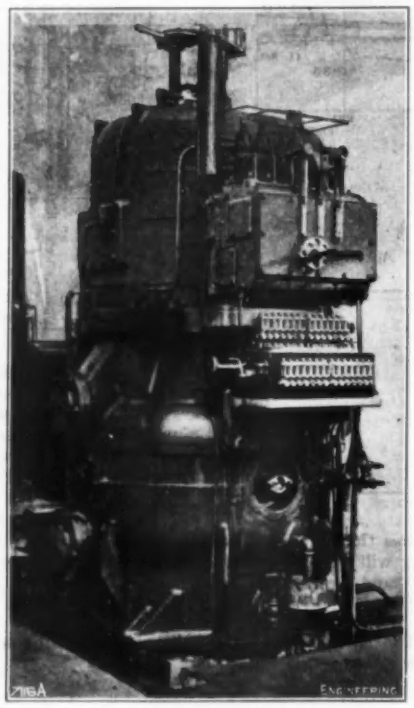


FIG. 90.

in proportion to the number of rings, but the "additional" friction remains constant. In these experiments, the "elastic" pressure was 0·5 atmospheres; the additional constant gas pressure was 15 atmospheres. The temperature was 84 deg. C. and the piston speed 2 m. per second. The influence of temperature is illustrated by the diagrams given in Fig. 81, in which the viscosity of the oil η is shown together with the temperature on the base line. The elastic ring pressure was 0·88 atmospheres and the additional constant gas pressure 10 atmospheres. The piston speed was 2 m. per second. The temperature influence is of special interest. The "elastic" friction falls with the temperature as the viscosity falls, but the "additional" friction seems to be independent of the viscosity. To find the theoretical explanation for this we may consider an oil-film friction between parallel plates with rounded edges of radius ρ. Using the nomenclature of Fig. 88, on this page, the friction

$$R = D\,\pi\,a\left(\frac{8\sqrt{2}}{3\,\pi}\right)^{\frac{4}{3}}\left(\frac{\eta\,c}{\rho}\right)^{\frac{1}{3}}\Sigma\,\Delta\,p^{\frac{1}{3}}$$

where

$$\Delta\,p = p_{last} + \frac{1}{2}\,\delta\,p_{ring}.$$

Instead of using a resulting coefficient of friction $\mu = \frac{R}{P}$, we may subdivide it into a coefficient of friction corresponding to the "elastic" friction only:—

$$\mu_{elast} = \frac{R_{el}}{P_{el}}$$

with

$$P_{el} = D\,\pi\,a\,.\,i\,.\,p_{el}$$

and a coefficient of the additional friction:—

$$\mu_{\delta} = \frac{R_{tot} - R_{el}}{P_{\delta}}$$

with

$$P_{\delta} = D\,\pi\,a\,.\,p_{tot}$$

and

$$p_{tot} = \Sigma\,\delta\,p_{ring}.$$

If we introduce, for example, the following values into these formulæ:—

η = 0·0003 kg. sec. m^{-2}.
ρ = 5/100·10^{-3} m.
c (piston speed) = 4 m. per second.
p_{el} = 1 atmosphere.

we shall find, for a constant gas pressure before the first ring taken between zero and 20 atmospheres, and a number i of rings:—

i	=	1	6
μ_{el}	=	0·15	0·15
μ_{δ}	=	0·05-0·06	0·04

For a comparison, some experimental curves of the coefficient of friction was shown in Fig. 85, page 297. The theoretical values of μ_{el} and μ_{δ} and the temperature influence (viscosity) for μ_{el} is confirmed, while for μ_{δ} no special temperature influence has been observed.

In concluding this section on piston-ring friction, reference may be made to Fig. 82, Plate XVI, which shows a series of slow-down diagrams. For large rings* and a low temperature we found fluid friction even at piston speeds of 2 m. per second. The slow-down diagrams show that at lower speeds the friction first diminishes and then increases to semi-fluid friction, especially at low speed near the dead centre.

PRACTICAL APPLICATIONS.

After having discussed some of the problems of the internal-combustion engine, it may be of interest to consider how the results that have been obtained are applicable to modern engine development. As an example, aircraft research work may be mentioned. Such work is concerned not only with heat-flow, temperature stresses and cooling conditions of the piston, the cylinder head and the exhaust valves, but also with the problems of fuel injection. It seems possible, for example, to increase the output of aircraft engines by supercharging with an exhaust-driven turbo-blower; this is only practically possible, however, when it is applied in connection with the scavenging of the combustion chamber, as in the Büchi system. It is possible that higher output will also be reached with the two-stroke principle. Both solutions demand fuel injection, whether the machine is built as a petrol or as a Diesel engine.

For the development of heavier engines, however, the work of the engineer must be accompanied by more and more detailed research. Let me choose as an illustration one example only. During the past

* H. Horgen. Neue Versuche über Kolbenring-reibung. Diss. E.T.H., Zürich. (In preparation.)

* Especially the Davy Robertson rings, all of which sealed well after a very short running-in, and which had the lowest coefficient of friction of any that we measured, though not the lowest friction force, on account of their being very wide.

few years, I have had the opportunity of following closely a development which has now shown its first results. I mean the free-piston generator developed by the Pescara Group. The free-piston generator is based on the principle of the free-piston compressor. An opposed-piston two-stroke engine gives its whole energy to two compressor pistons, each of which is directly connected to a motor piston. As the reciprocating motion of the pistons is limited only by the gas pressures, the work of the motor and of the compressor must balance at the end of every stroke (not only at the end of every cycle); that is to say, the resulting mean gas force over each stroke must be zero, as shown in Fig. 83, Plate XVI. The work furnished by the expansion of the gas during the first part of a stroke is stored as kinetic energy of the moving pistons and then absorbed at the end of the stroke by the work required for the compression of the gas. For every position of the piston, the conditions

$$\int_0^x \text{Pres}\, d\, s = \frac{m\, v^2}{2}$$

and

$$\int_0^x \frac{d\, s}{v} = t$$

must be fulfilled.

The load of the free-piston engine can be regulated by changing the stroke, but as the compression curve of the motor should not change, the work of the compression stroke must be the same for a long full-load stroke as for a short no-load stroke. Fig. 87, page 297, shows how the increasing expansion work of the compressor cylinder can be compensated by the diminishing work of an additional air cushion. An air-cushion cylinder can, for example, be arranged at the rear side of the motor piston. A small compressor of this design in our Institute is illustrated in Fig. 84, Plate XVI. Around it is arranged apparatus for measuring optically the vibrations of the compressor-valve blades.

A very promising development of the free-piston engine for stationary and marine purposes is its application as a gas generator. Indeed, by scavenging and supercharging the motor cylinder with the total amount of air delivered by the compressor, at, for example, 4 atmospheres, the whole power of the engine is made available in the form of compressed exhaust gases of 4 atmospheres at about 420 deg. C. A number of free-piston generators can be arranged to drive a gas turbine under very moderate temperature and pressure conditions. The solution of the various problems involved in this application of this engine will require much intensive study.

It is necessary in the first place to have good basic data to establish the theoretical diagrams from which we can determine the pressure rise and the piston stroke at all possible loads. Fig. 86, page 297, shows, for an exhaust pressure of 4 atmospheres absolute, the entropy and indicator diagrams for different loads and strokes, calculated with the entropy diagram described in Lecture IV (page 682, vol. 148). The heat loss through the cylinder walls can be calculated in the same way as was shown, for normal engines, in Fig. 54 of that lecture. It then appears that the total heat loss through a given wall surface is, for the generator, about 16 per cent. higher than for a normal two-stroke engine with opposed pistons. But the heat loss in relation to the horse-power output owing to high supercharging is only about 65 per cent. of the normal loss of a two-stroke engine. The fuel injection is complicated by two factors: first, the size of the combustion chamber changes with the load; and second, in the dead-centre position the engine has no moving parts at all, so that a short-stroke delivery pump will have finished its injection stroke long before the dead centre. Therefore, an accumulating system, where the fuel is stored, and the injection started before the dead centre, would be of value. Furthermore, to enable us to design an uncooled piston of, for example, 300 mm. bore, for a high-pressure supercharged two-stroke Diesel engine of this kind, the temperature field and the temperature deformations and stresses in the engine must be known. Pistons of this kind have shown most satisfactory results in actual operation. As the engine has practically no bearings, the piston-ring friction has a preponderant influence on the mechanical losses and even on the resulting piston speed and stroke. In addition to the friction of the motor piston rings, that of the compressor and air-cushion piston rings must be considered.

A very important problem, especially for the free-piston engine, is that of the automatic compressor valves. Fig. 89, opposite, shows a comparison, measured some time ago in the Institute, of two types of normal non-return valves, used for the scavenging ports of two-stroke engines or as scavenging-pump valves. One consists of a flexible steel strip and the other takes the form of a spring-loaded plate. They have the same maximum free section, but are quite different in so far as maximum and opening pressures are concerned. Optical diagrams show that the steel-strip valve sets up vibration. For high speed, a special diffuser valve has been developed and tested in our Institute.

The first free-piston generator to be built is shown in Fig. 90, opposite. It is a vertical machine of 300 mm. (about 12 in.) engine-cylinder bore, and can develop a maximum of 800 h.p. It is now running on the test bed at Alsthom, Belfort. The first important non-stop run up to the present has been one of 40 hours at 600 h.p. and about 500 cycles per minute. It is interesting to note that the behaviour of the uncooled pistons, so far, has been entirely satisfactory. The weight of the generator is less than 5 kg. per horse-power. As the heat loss per horse-power is relatively small, and as the exhaust heat will be partly transformed into useful work in the turbine, the fuel consumption per brake horse-power at the shaft of the turbine will, in accordance with the theory, be comparable with that of a Diesel engine. This was substantiated by the practical results.

To observe the variations of the stroke of the free pistons under different running conditions, such as supercharging (*i.e.*, with the exhaust pressure varying from 1 atmosphere to 3·5 atmospheres absolute); change of air-cushion pressure (*i.e.*, change of engine compression); and variable quantity of fuel injected, the length of the stroke was recorded directly on a diagram, and showed a very reliable control of the engine. I trust that this concrete example of the free-piston engine may have illustrated the practical bearing of the new theoretical and experimental investigations on which we have been engaged.

THE ENGINEERING OUTLOOK.

IX.—Locomotives and Rolling Stock.

The year 1939 was again a relatively prosperous one for British manufacturers of locomotives and rolling stock. Exports, up to the outbreak of war, were not quite up to the level of the previous year, but, against this, important new orders were booked, notably for Turkey, and, later in the year, for the use of the British Army in France. In addition, a number of locomotive builders also had work in hand under the armament programme. Most manufacturers were able, therefore, to show improved financial results, and in at least one case, that of the North British Locomotive Company, extensions to plant have been necessary.

As regards main-line locomotives, builders other than the railway companies, up to the outbreak of war, were entirely dependent on export orders. This fact was commented on by the chairman of the Vulcan Foundry, Limited, at the annual meeting of the company in April, 1939. In referring to the "square deal" demand by the railways, he hoped that they would appreciate the desirability of themselves giving a square deal to the locomotive builders, expressing the conviction that both the railways and the locomotive builders would benefit to no small extent if it were found possible to place part of their annual requirements with the old-established locomotive-building firms. Very similar remarks were also made by the chairman of Beyer, Peacock and Company, in the following month.

Actually, the home demand for locomotives has been materially affected by the policy of standardisation adopted by the railway companies in recent years. This has greatly reduced the number of types of locomotives necessary for any given traffic, and, by making possible a more intensive use of the locomotives in service, has also reduced the total number required. During 1939, virtually no new design of locomotive appeared, and production was concentrated on mixed-traffic locomotives, which have the widest range of application.

The programme of the L.M.S. Railway comprised 90 locomotives and 271 additional boilers. Of the locomotives, 20 were streamlined Pacifics, 35 were mixed-traffic engines, 15 heavy freight tender engines, and 20 passenger tank engines for suburban service. There was also a good deal of construction left over from the 1938 programme, including 30 mineral engines of the 2-8-0 type and six of the 0-6-0 type. The L.N.E.R. programme comprised 50 six-coupled locomotives of the V2 class and 10 tank engines, and actual construction at Doncaster and Darlington included about 30 of the former and about a dozen V1-class locomotives. In addition, the Gorton Works of the old Great Central Railway, which had for some years been engaged solely on repair work but which resumed new construction in 1938, produced 10 shunting tank engines in 1939. As usual, a considerable number of locomotives were rebuilt or modified during the year. A number of new locomotives were built by the Great Western Railway at Swindon, including some 20 of the 4-6-0 Grange type, 7 of the Manor type, and 10 of the Castle type. In addition, six 2-8-0 mineral locomotives were built and a number of 4-4-0 passenger and 0-6-0 freight engines, as well as various tank engines. Owing to the degree of electrification already carried out, new construction by the Southern Railway has not been on a large scale for some years. In 1939, nine Q-class 0-6-0 freight and mixed-traffic locomotives were constructed at Eastleigh. The remainder of the work consisted entirely of rebuilding and modifications.

No full programmes for 1940 have been or are likely to be published, but, quite apart from the orders placed with independent firms for locomotives for the use of the British Army in France, the railway companies are likely also to expand their output. At the beginning of the war, some 300 2-8-0 engines, drawn from the London and North Eastern and Great Western Railways, were sent to France. These were built for R.O.D. service during and just after the last war. In addition, approximately 100 Great Western 0-6-0 engines were sent overseas. Though not all of these will be necessarily

TABLE I.—*Locomotives: United Kingdom Exports.*

Monthly Average.	Volume.	Index. (1913 = 100.)	Value Per Ton.	Index. (1913 = 100.)
	Tons.			
1913	3,927	100	59·0	100
1931—				
1st Qr. ..	2,839	72	77·0	130
2nd ,, ..	1,422	36	80·8	136
3rd ,, ..	1,881	47	67·6	114
4th ,, ..	475	12	80·6	136
1932—				
1st Qr. ..	386	10	103·0	174
2nd ,, ..	320	8	93·2	157
3rd ,, ..	191	5	93·2	157
4th ,, ..	154	4	94·5	160
1933—				
1st Qr. ..	488	12	138·7	235
2nd ,, ..	1,296	33	82·4	140
3rd ,, ..	821	21	75·2	127
4th ,, ..	520	13	76·6	130
1934—				
1st Qr. ..	306	8	94·1	159
2nd ,, ..	133	3	142·4	241
3rd ,, ..	136	3	161·4	273
4th ,, ..	1,012	26	80·6	254
1935—				
1st Qr. ..	937	24	80·1	136
2nd ,, ..	210	5	107·0	181
3rd ,, ..	869	22	89·3	151
4th ,, ..	1,434	37	81·1	137
1936—				
1st Qr. ..	1,745	44	85·7	145
2nd ,, ..	1,316	33	91·8	155
3rd ,, ..	861	22	94·2	159
4th ,, ..	655	17	126·8	215
1937—				
1st Qr. ..	1,096	28	110·1	187
2nd ,, ..	647	17	100·6	171
3rd ,, ..	806	21	111·9	190
4th ,, ..	1,071	27	94·2	160
1938—				
1st Qr. ..	988	25	111·2	189
2nd ,, ..	1,383	35	105·2	178
3rd ,, ..	1,365	34	108·9	185
4th ,, ..	1,535	39	108·8	185
1939—				
1st Qr. ..	1,151	33	111·8	189
2nd ,, ..	1,179	33	122·5	214
3rd ,, ..	953	25	132·4	233

replaced immediately, it is understood that the L.N.E.R. is building more 2-6-2 and 2-8-0 type locomotives in replacement. Provision has also been made for the loan of steam locomotives between the various companies, in the event of dislocation of the electrified lines. The L.N.E.R., for example, would lend locomotives to the Southern and the London Passenger Transport Board.

Turning to consideration of the independent companies, British exports of locomotives in the period January to August, 1939, totalled 8,996 tons, valued at 1,068,000*l.*, compared with 9,735 tons, valued at 1,056,126*l.*, in the corresponding period of the previous year. Quarterly exports are shown in Table I, page 299, from which it will be seen that there was a considerable fall in the first quarter of 1939 from the high level ruling at the end of 1938, and, although exports were well maintained in the second quarter of the year, there was a further drop in the third quarter. Actually these figures reflect the falling off in orders received during 1938, but as regards the level of activity in the industry, the position was largely retrieved by the improvement in orders received during 1939. A notable feature of Table I is the steady rise in average value per ton during 1939 to one of the highest figures ever recorded, namely, 132·4*l.*, in the third quarter of 30 boilers valued at 67,259*l.* The company also received a substantial share of the orders for the B.E.F., mentioned above.

Beyer, Peacock and Company, Limited, delivered four double-Pacific Beyer-Garratt locomotives to the Nigerian Railways and six locomotives to the Kenya and Uganda Railways. These latter, which weigh 186 tons each, are believed to be the heaviest locomotives running on 50-lb. rails. The company had six further locomotives under construction for the same market. They also delivered some 2 ft.-gauge Garratts to South Africa, and seven 3 ft. 6 in.-gauge locomotives to the Gold Coast.

The Vulcan Foundry, Limited, were largely engaged on work for India, and had under construction some 26 broad-gauge locomotives of various classes. Considerable interest was taken in Indian conditions during 1939 on account of the Pacific Locomotive Committee's Report, the origin of which was the Bihta derailment on the East Indian Railway. The Committee, whose work has been previously dealt with in our columns, was set up to consider the suitability of Pacific engines of the type employed in India for more than ten years, and the justification for their purchase. The main conclusion was that the introduction of Pacific engines was justified and that they should give many years of reliable work provided that they were modified, that attention was paid to particular aspects of track and locomotive maintenance, and that speed limits were imposed according to local conditions.

It was stated that the X-class Pacific locomotives were sensitive to defective track and poor maintenance, and that a large amount of work could be more economically undertaken with improved and modernised engines of the type recommended by the former British Engineering Standards Association. The report concluded by recommending an enlarged organisation for research and standards, to enable India to deal with her own problems, including the building of broad-gauge locomotives. In July, 1939, it was stated that the Indian Railway Board, after due discussion, had come to the conclusion that the construction of broad-gauge locomotives in one of the existing railway workshops in India might not prove unremunerative.

In June, 1939, the North British Locomotive Company and the Vulcan Foundry received orders for a total of 43 superheated boilers for the North Western Railway of India. For the year 1940-41, the Fiscal Committee approved expenditure of Rs. 1,60,75,000 for locomotives and boilers and Rs. 96,00,000 for coaching stock. The locomotive programme included the purchase of 37 additional engines, at a cost of Rs. 64,00,000, to cope with the increased traffic on the East Indian Railway, as well as a number to replace existing locomotives.

During 1939 an important contract for 58 locomotives, valued at about 1,000,000*l.*, was received from Turkey. Of the total order, 24 engines were to be built by Beyer, Peacock and Company, 24 by the Vulcan Foundry, and ten by Robert Stephenson and Hawthorns. These orders, which resulted from the granting of a commercial credit to Turkey, were particularly satisfactory in view of the fact that Turkey had formerly relied mainly on German sources for railway material. The orders in question were, in fact, for German-type locomotives and, in order to obtain the contract, British manufacturers had to accept the condition that certain accessories must be obtained from Germany. In November, 1939, it was stated that the Turkish railways would shortly undertake themselves the production of locomotive parts, notably fireboxes. The newly-opened railway works at Sivas were equipped to produce some 700 goods wagons per annum and to overhaul 800 goods wagons and 120 locomotives.

In the Egyptian market, where keen competition has existed for some years, British firms lost an important order during 1939 to Polish manufacturers. Tenders for 16 2-6-0-type locomotives and tenders were received by the Egyptian State Railways from three British, one Polish, three Belgian, three German, one Swiss, and one Czech concern. The lowest tender, £E.7,050, was from Poland, while the lowest British tender was £E.9,850 from the North British Locomotive Company.

International exports of locomotives are shown by volume in Table II, on this page, and by value in the accompanying Table III. German exports, both by volume and value, increased as a percentage of the total exports from the countries shown, in the former case from 62·9 per cent. in 1938 to 64·0 per cent. in the first eight months of 1939, and in the latter from 51·4 per cent. to 55·2 per cent. British exports showed little change by value, but declined from 32·5 per cent. to 27·5 per cent. by volume. Exports from the United States, available by value only, showed a sharp decline, and those from France, which do not constitute a large proportion of the total, increased considerably.

TABLE II.—INTERNATIONAL EXPORTS OF LOCOMOTIVES. (VOLUME, TONS).

	1933.		1934.		1935.		1936.		1937.		1938.		1939.*	
		Per cent.		Per cent.		Per cent.		Per cent.		Per cent.		Per cent.		Per cent.
United Kingdom	8,021	56·5	4,760	64·5	10,466	47·3	13,720	54·9	10,856	41·8	15,769	32·5	8,996	27·6
Germany	2,124	17·6	2,052	27·8	9,693	43·7	9,283	37·1	12,686	48·8	30,764	62·9	20,884	64·0
France	1,922	15·9	569	7·7	1,998	9·0	1,999	8·0	2,446	9·4	2,278	4·6	2,770	8·5
Total	12,067	100·0	7,381	100·0	22,157	100·0	25,002	100·0	25,988	100·0	48,811	100·0	32,650	100·0

TABLE III.—INTERNATIONAL EXPORTS OF LOCOMOTIVES. (VALUE, £000.)

	1933.		1934.		1935.		1936.		1937.		1938.		1939.*	
		Per cent.		Per cent.		Per cent.		Per cent.		Per cent.		Per cent.		Per cent.
United Kingdom	734	56·8	453	54·5	891	42·7	1,301	55·9	1,130	45·6	1,715	32·3	1,068	32·1
Germany	200	15·5	164	19·7	800	38·4	706	30·3	943	38·0	2,730	51·4	1,834	55·2
United States	55	4·3	124	14·9	166	8·0	105	4·5	266	10·7	667	12·5	179	5·4
France	302	23·4	91	10·9	226	10·9	216 ..	9·3	141	5·7	201	3·8	244	7·3
Total	1,291	100·0	832	100·0	2,083	100·0	2,328	100·0	2,480	100·0	5,313	100·0	3,325	100·0

* January to August.

Since export figures are not available for 1939, according to countries of destination, an idea of the principal markets can only be obtained from a review of the work carried out by the principal locomotive builders. The North British Locomotive Company delivered, during 1939, 44 main-line locomotives for the South African Railways, and six tank engines for the Federated Malay States Railways. The former were large engines, weighing 109 tons without tender. The company also began delivery, towards the end of the year, of the 40 large locomotives, weighing 108 tons, ordered by the New Zealand Government Railways. An order for 30 of these was placed towards the end of 1938 and, as urgent delivery was required, it was arranged that they should be delivered not later than November, 1939. Later, the order was supplemented by a further order for ten locomotives. The value of the whole contract was recorded as 450,905*l.* Towards the end of 1939, the company also had on hand a good deal of work for India. In July it was announced that orders had been received from the North Western Railway of India for 15 locomotives and tenders and 17 duplicate locomotive boilers, and from the East Indian Railway for 16 boilers. In December, further orders were placed from South Africa, comprising

Quite apart from exports from Germany proper, the war will result in the cutting off of exports to overseas countries from Czechoslovakia and Poland, which, though not large in the aggregate, have been assuming an increasing importance in recent years. In 1938, the principal German export markets were South Africa (14,625 metric tons), Turkey (3,916 metric tons), Brazil (3,444 metric tons) and the Argentine (3,153 metric tons). Exports to all these countries, as well as to several others of lesser importance, are likely to be entirely cut off, so

that a very large field will be open to British manufacturers.

In the past, German locomotive builders have had a considerable advantage over their British competitors in that they have had a reasonably steady home demand, which has enabled them to quote low prices in export markets quite apart from any subsidies which they might receive. As a result, the director of Henschel and Sohn G.m.b.H. was able to claim recently that, in the period 1927 to 1938, Germany had exported to South Africa alone 600 locomotives and 500 boilers; about double the deliveries from England. Similarly, in the period 1930 to 1938, German exports to South America totalled about 300 locomotives, or eight times the United States exports to those countries. If the British industry is to be firmly established after the war, some means will have to be found for providing a steady background of orders from the home railways.

Rolling Stock.—The rolling-stock industry also had a prosperous year in 1939. There was a slight recession, however, in the number of insured workpeople, from 58,610 at July, 1938, to 53,910 at the corresponding date in 1939, and, although the number unemployed fell from 2,977 to 1,634, there was a fall in the number actually in employment from 55,633 to 52,276. Employment figures are shown in Table IV, herewith.

British exports of railway carriages and wagons shown in Table V, below, have been very irregular in recent years. In the first eight months of 1939, exports of carriages increased to 371,000*l.*, compared with 197,000*l.*; but exports of parts

TABLE IV.—*Employment in the Railway Carriage and Wagon and Tramcar Industry.*

Date.	Number of Workpeople.			
	Insured.	Unemployed.	Employed.	Index, 1924 = 100.
July, 1924 ..	52,180	2,774	49,406	100
,, 1928 ..	56,370	6,315	50,055	101
,, 1929 ..	54,210	4,904	49,306	100
,, 1930 ..	54,090	6,086	48,004	97
,, 1931 ..	51,550	11,675	39,875	81
,, 1932 ..	49,130	12,720	36,410	74
,, 1933 ..	45,180	9,770	35,410	72
,, 1934 ..	46,410	5,717	40,693	82
,, 1935 ..	46,790	3,269	43,521	88
,, 1936 ..	49,660	2,157	47,503	96
,, 1937 ..	50,610	1,689	48,921	99
,, 1938 ..	58,610	2,977	55,633	113
,, 1939 ..	53,910	1,634	52,276	106

fell from 385,000*l.* to 283,000*l.*, of complete wagons from 1,188,000*l.* to 432,000*l.*, and of parts for wagons from 403,000*l.* to 287,000*l.* One of the largest orders received from export markets was a contract from the Turkish State Railways, placed with the Metropolitan-Cammell Carriage and Wagon Company, Limited, acting on behalf of a group of British rolling-stock builders, for 300 wagons,

TABLE V.—*Exports of Railway Carriages and Wagons.* (£000.)

—	Carriages.	Parts.	Wagons.	Parts.	Total.
1924 ..	340	856	1,438	1,809	4,443
1928 ..	1,786	689	952	1,402	4,829
1929 .	1,417	1,002	1,427	338	4,184
1930 ..	1,036	809	1,952	796	4,593
1931 ..	787	382	566	212	1,947
1932 ..	281	119	219	48	667
1933 ..	85	215	119	106	527
1934 ..	211	212	323	226	972
1935 ..	37	222	676	286	11,221
1936 ..	349	262	583	248	1,442
1937 ..	1,513	402	549	327	2,791
1938 ..	272	592	1,481	622	2,967
1939 .. (Jan.-Aug.)	371	283	432	287	1,373

valued at 500,000*l.* The wagons, of the steel hopper type, are of a special design for the transport of iron ore and coal for the Government, steelworks at Karabuk. Another important order, from the Southern Railway, Argentine, was received by the firm of Hurst, Nelson and Company, for the supply of ironwork for the conversion of cattle wagons. The company also had under construction a 150-ton railway truck for the Anglo-Iranian Oil Company. In July, it was announced that the New South Wales Railways had allocated 750,000*l.* for the purchase of rolling stock and other railway equipment.

In the home market some important orders were placed early in 1939 by the London and North Eastern Railway in connection with its electrification programme. The company ordered 100 60-ft. motor coaches and 100 55-ft. composite trailer coaches from the Metropolitan-Cammell Carriage and Wagon Company; and 100 55-ft. driving trailer coaches from the Birmingham Railway Carriage and Wagon Company. The Gloucester Railway Carriage and Wagon Company reported some important orders from the London Passenger Transport Board.

In general, the carriage and wagon builders have fared better in recent years as regards the home demand than have the locomotive manufacturers. Not only have they received more orders from the railway companies but, in addition, there is a more widely spread industrial demand, and repair work has been quite appreciable. For example, various colliery companies purchased a number of wagons during 1939, and the firm of Hurst, Nelson and Company reported orders for tank wagons from Imperial Chemical Industries, Limited, and from the Air Ministry. In addition, as in the case of locomotives, important orders were placed for rolling stock for the use of the Army in France. These comprise 10,000 20-ton goods wagons, for which orders have been distributed between the Metropolitan-Cammell Carriage and Wagon Company, the Birmingham Railway Carriage and Wagon Company, the Gloucester Railway Carriage and Wagon Company, Hurst, Nelson and Company, G. R. Turner, Head, Wrightson and Company, Cravens Railway Carriage and Wagon Company, Charles Roberts and Company, R. Y. Pickering and Company, and the Butterley Company.

In September, 1939, the Minister of Transport requisitioned all privately-owned railway wagons, other than tank wagons and certain other special types, and vested the Railway Executive Committee with power to use or deal with the requisitioned wagons. The regulation was made to ensure more intensive use of wagons, but it was found that considerable delays still occurred in connection with loading and unloading. It was decided, therefore, as from December 15, to increase demurrage rates. These developments are not without influence on the wagon-building industry, particularly if, as is quite possible, it should be decided eventually to abolish private ownership of wagons. This might reduce the volume of work available to the independent manufacturers if the railway companies should decide to cover an increased proportion of their requirements. Whatever the developments may be in this connection, it is important, in order to give a firm basic load on which exports can be built up, that the railways should continue to place orders with the carriage- and wagon-building companies.

Further developments took place during 1939 in connection with shock-absorbing wagons. The L.M.S. Railway decided to construct a further 300 of such wagons, bringing the number in service up to 506. In addition, six shock-absorbing vans introduced experimentally on the Great Western Railway in 1938, proved so successful that the company decided to fit 100 open and 100 covered wagons with shock-absorbing equipment.

THE PLATINUM METALS.—The output of the platinum metals, namely, platinum, palladium, iridium, rhodium and ruthenium, in the world during 1939 is estimated to have totalled about 500,000 oz. This figure represents an increase of some 40,000 oz. over the total for 1938.

CANADIAN IMPORTS OF COAL.—During the ten months ending October 31, 1939, Canada imported 10,777,139 tons of coal, compared with 10,936,888 tons in the corresponding period of 1938. Anthracite imports, during the 1939 period, increased by 38 per cent., as compared with the 1938 period, to 2,303,484 tons. On the other hand, the United Kingdom supplied only 903,633 tons, against 996,894 tons in the first ten months of 1938. Anthracite imports from January totalled 290,126 tons, compared with 340,940 tons in the 1938 period, and French Indo-China supplied 43,537 tons. Imports of bituminous coal during the first ten months of 1939 consisted of 7,174,714 tons from the United States and a mere 61,625 tons from the United Kingdom. A small cargo, amounting to 220 tons, was also received from Norway.

LITERATURE.

Collected Researches on Cylinder Wear. By C. G. WILLIAMS, M.Sc. London: The Institution of Automobile Engineers Automobile Research Committee. [Price 10s.]

THIS book presents, in a convenient form, the results of several years' work on the subject of cylinder wear; a matter of importance not only to automobile engineers but to all manufacturers and users of internal-combustion engines. On several occasions we have referred to the value of the researches conducted first at Chiswick and later at the Great West-road laboratories of the Institution of Automobile Engineers, and therefore welcome this re-issue of the four interim reports in one volume, which permits the engineering industry as a whole to benefit by the valuable information there available, upon what Lord Austin, in his foreword, describes as "this elusive problem." The Automobile Research Committee consists of engineers who are staff officers of important industrial undertakings, and the Director of Research, Mr. C. G. Williams, has the particular advantage not only of their co-operation but of their constructive criticism while the reports are still in draft form. From the scope of the investigations summarised in the collected researches it is evident that the various aspects of cylinder wear have been presented, considered and decided in a manner which practical men will thoroughly appreciate.

Before any laboratory work was undertaken, an investigation was made of information published on the subject prior to 1931, and manufacturers and operators of private cars and commercial vehicles were asked to give their experiences for general guidance. Six years later (1937), after four interim research reports had been issued, manufacturers and operators were again invited to express their opinions whether, in their experience, the rate of cylinder wear had been reduced as a consequence of the better knowledge then available. It is by such inquiries that the value of research work can be reliably assessed and in this case it is evident that normal evolutionary progress, in the meantime, had somewhat influenced matters. For example, while engines on private cars had shown improvement, manufacturers of commercial vehicles had developed the compression-ignition engines, using gas oil, in place of the petrol engine; but, generally, it was agreed that cylinder wear as a problem was no longer of prime importance, and that the wear of bearings had become the criterion for deciding the period between major overhauls.

One of the first discoveries during the research investigations was the detrimental effect of cold cylinders, especially when starting from cold. It has since been conclusively proved that engines fitted to vehicles used for numerous short trips, such as tradesmen's delivery vans, have a high rate of cylinder wear, while the lowest rate of wear recorded is for sports cars used on the race track or on long journeys. A further interesting fact brought out in these reports is that, while a goods delivery vehicle used for door-to-door work has usually a high rate of cylinder wear, the same type of vehicle working in hilly country shows considerably less wear, because of the higher general temperatures while in operation. Another case is cited of two similar engines set to run on a test bench, one with the jacket-water temperature at 165 deg. F., while the other was at 65 deg. F. At the conclusion of the test the hot-running engine was found to be in perfect condition while the cold-running engine had the cylinder walls, pistons and rings covered with rust and was badly worn. The investigations into cylinder-wear variation have covered various aspects of lubrication, both as to quality and quantity of the oil in circulation and also the use of flushing oils after sumps have been drained. Cylinder materials have been studied under what is termed "moderate" and "severe" conditions. Piston-ring material, radial pressure, and width; air cleaners and filters, and the use of thermostats, have also been subjects for experiment and the results are given concisely and clearly in the reports.

Of the many research associations in which the Department of Scientific and Industrial Research takes an interest, the Automobile Research Com-

mittee is unique in that it is run under the ægis of a chartered institution of engineers and is not directly controlled by the industry which subscribes to its funds and benefits by its work. The valuable results that are being obtained, not only in the matter of cylinder wear but on many other problems of general interest to the engineering industry, point to the fact that the direction of research matters by a combination of professional and industrial engineers has much to commend it.

A Practical Manual of Chemical Engineering. By HAROLD TONGUE, M.I.Mech.E. London: Chapman and Hall, Limited. [Price 36s.]

IT is not generally recognised that chemical engineering is no new thing. In 1901, for example, the late Mr. George E. Davis published a handbook on the subject, based on lectures which he had delivered in the Manchester Technical School in 1887. While, however, modern chemical engineering may be said to have grown up during the last war, and to have attained its majority with the Chemical Engineering Congress in 1936, there are still gaps in the literature requiring to be filled. The book under review should go far to fill some of them, though, as the author observes, the field to be covered is now too wide to be covered exhaustively and the subject-matter represents, therefore, only a selection of the more important and typical aspects which are of practical importance.

About one-third of the book is devoted to materials of construction, comprising non-ferrous metals, cast iron and iron alloys, steels and alloy steels, and non-metallic materials, such as stoneware, silica, rubber, etc. The properties of these materials at high, normal and low temperatures, are described, and their uses in the manufacture of different chemical products are discussed. The attention given to small but vital details will be appreciated by those who have suffered from the neglect of points that may appear unimportant to the non-chemical mind. A chapter follows on the design and construction of pressure vessels for the chemical industry, a subject on which the author writes with particular authority by reason of his experience with the Chemical Research Laboratory of the Department of Scientific and Industrial Research. Subsequent chapters deal with pipes and pipework, heat insulation, and steam plant for chemical works.

In the 74 pages devoted to evaporators, the author treats of the flow of fluids in tubes in relation to heat transfer, flow outside tubes, and the important question of condensing vapours; and deals in turn with the more important types of evaporators, including those employing vapour recompression. Some 20 pages are devoted to drying, while a short chapter examines adsorption processes depending on the liquid phase as well as the vapour phase. The thorny subject of distillation is dealt with at some length. The closing chapters cover filtration, crushing and grinding equipment, and pumping plant. Safety in relation to design and operation is discussed in a brief appendix. Separate indices are given to authors and subjects.

The author has performed some notable feats of compression, and, if a more detailed treatment of certain of the subjects might be thought desirable, it must be admitted that, as a choice was necessary to keep the size of the book within reasonable limits, it has been well made on the whole. The book is well illustrated and produced, and is a useful addition to the literature of chemical engineering, but the inclusion of advertisements at the end is regrettable.

The Physical Examination of Metals. Volume I. By DR. B. CHALMERS. London: Edward Arnold and Company. [Price 14s. net.]

SINCE the numerous uses to which physical methods are now put in the study of metals together constitute only one instance of the general tendency towards a physical interpretation of atomic structure, an acquaintance with the advances already made should open up fruitful fields of research for students of metallurgy. It is not difficult to realise that progress in this direction has depended in no small measure on the adaptation of physical apparatus to particular circumstances, as is well exemplified by the gradual development of the spectrograph for use in the routine analysis of a large number of similar substances. To the essential literature on the subject, Dr. Chalmers has added, in what is intended to be the first part of a two-volume work, a fairly complete description of the examination of metals by optical means. The text bears the stamp of experience, as do also the references to original papers, for it embraces not merely the relation between theory and practice, but also an appreciation of the limitations to the various techniques.

After a brief account of the visible spectrum, the author proceeds to describe how the reflection of light can be employed for the purpose of exhibiting surface irregularities on tinplate and similar materials. This is a matter of primary importance in the microscopical examination of metals, because the process of etching may affect a surface in different ways, disclosing either the phases or the constituent crystals by the amount and colour of the reflected light that enters the microscope. These sections on geometrical optics are followed by two chapters on wave optics which deal in succession with applications of interference and diffraction. Here is shown the use of the phenomenon of interference as an instrument for surveying the micro-topography of flat surfaces such as those of limit gauges, and for measuring the thickness of a thin wire or a foil or an electro-deposited layer. The same pages also merit the attention of the student of engineering who is interested in the utilisation of interference in the measurement of relatively small movements between two parts of an instrument, and of the elastic constants of a specimen. The second phenomenon, arising from the mutual destruction of light-waves at points where they are out of phase, is studied under the heading of diffraction, in sections devoted to the measurement of objects separated by extremely short distances, to the resolving power of microscopes and the related subject of ultra-violet microscopy.

Due consideration is given to polarised light, in a discussion which is most conveniently divided into the two groups formed by macroscopic and microscopic methods. In the former case, the characteristics of the polarised light reflected from a surface, and especially a metallic surface, enable the investigator to study the physical and chemical states of the surface as a whole. In the latter case, slight differences between different parts of a given surface can often be detected, and the nature of the various phases sometimes determined, by microscopic analysis using polarised light. Within the compass of 180 pages, Dr. Chalmers has thus assembled a mass of serviceable information, including an introduction to the subject of spectrographic analysis.

The Theory of Structures. By PROFESSOR C. M. SPOFFORD. Fourth edition. London: McGraw-Hill Publishing Company, Limited. [Price 40s.]

ENGINEERS usually welcome text-books in which the principles of analysis and of detailing are discussed as complementary branches of the subject of design. In the present work, emphasis is necessarily placed on analytical considerations, but the balance between theory and practice is, nevertheless, evenly held; the subject-matter is well chosen, and the arrangement leaves little to be desired. This applies in particular to the chapters on beams and girders, roof and bridge trusses, the frameworks of industrial and multi-storey buildings, and three-hinged arches. The theory is then extended to the problems of statically-indeterminate systems and of wind-stresses in tall buildings. There are also instructive chapters on masonry structures consisting of dams and arches fixed at the abutments, which indicate the potential value of this course of study in drawing offices engaged on civil engineering.

In the preparation of this edition, Professor Spofford has brought his treatment into relation with the latest American specifications for structural systems, highway and railway bridges being notable examples. The careful manner in which these modifications have been introduced is best illustrated, perhaps, in the sections devoted to the revised formulæ for columns and for the inertia stresses associated with the movement of swing bridges. Students and practitioners in this country can hardly fail to benefit from these applications of American standards to typical problems of design, since the author brings the salient points into contact with general principles. Another commendable addition is the explanation and exemplification of the moment-distribution method of Professor H. Cross, given in Chapter XV. Although the book contains more than 600 pages, not much could be usefully omitted, either from the text or the numerous worked examples. There is room for improvement, however, in the brief account of the theory of earth pressure, in view of the investigations of Terzaghi and others, although this is of secondary importance in a work bearing the above title.

The price may be considered rather high for a work that is primarily intended for use in engineering colleges.

PROGRESS IN TIN RESEARCH.

THE successful electro-deposition of "white bronze," an alloy containing 60 per cent. of copper and 40 per cent. of tin, in the laboratory of the International Tin Research and Development Council, is given some prominence in the report of the Council for 1939. The coating is stated to have a pleasing silver colour and exceptionally high resistance to atmospheric corrosion, and plated articles are under trial as motor-car lamps and bumpers, shop fittings, refrigerator parts, lavatory fittings and table ware. The coating, it is of interest to note, consists of tin and copper in the proportions in which these metals are combined in speculum metal, of which the brilliant reflecting qualities were formerly utilised for hand mirrors and also for the mirrors of reflecting telescopes. Arrangements have been made to set up a full-scale plant for the technical development of the process in a works in Birmingham, and this, we understand, is now ready for commercial operation.

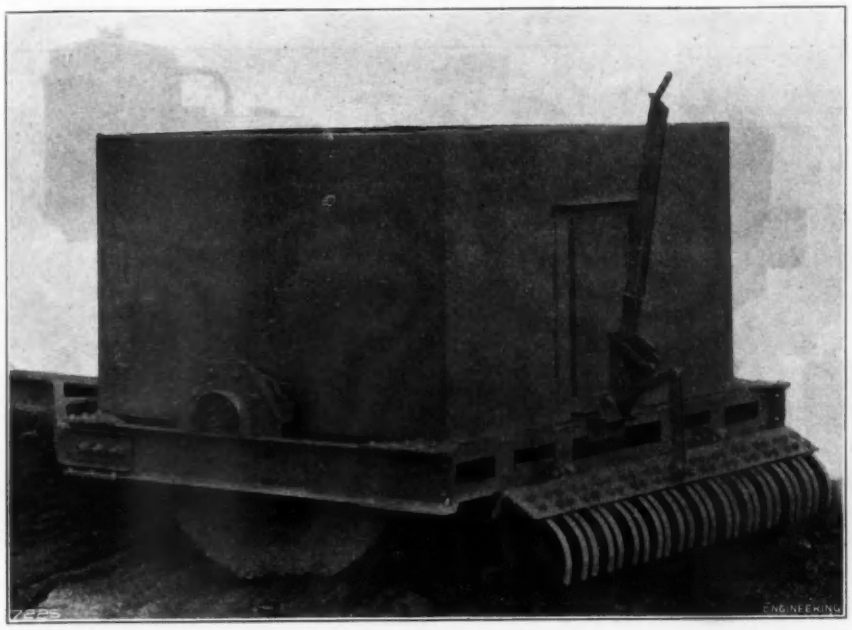
Another new development consists in the production of tin-rich alloys which have been found to possess strength and hardness values far in excess of those of commonly used materials of this type. The alloys belong to the tin-antimony-cadmium group, containing higher antimony contents (9 per cent. to 14 per cent.) than those investigated previously, and it is pointed out that a considerable range of properties can be obtained by suitable variation of the composition. Thus, if a hard alloy is required for a purpose for which ductility is unimportant, one having a Brinell hardness of 45, equal to that of copper, can be selected. If maximum tensile strength is needed, with some degree of ductility, then a second range of compositions gives tensile strengths of from 8 tons to 9 tons per square inch, with elongations of from 2 per cent. to 5 per cent. and Brinell hardness of from 41 to 43. If greater ductility is required, combined with high strength, a third range of composition gives tensile strengths of from 7 tons to 8 tons per square inch, with elongations of from 6 per cent. to 8 per cent. It is pointed out that the most ductile alloys of the group have tensile strength of from 5 tons to 6 tons per square inch, and elongations of from 15 per cent. to 25 per cent. Twenty-five of the new alloys have been selected for special examination as bearing metals, and three, which possess the best combination of strength, hardness, stability at high temperatures, bond strength, anti-friction properties, and high melting point, have been selected for engine tests, which are now in progress at the laboratories of the Institution of Automobile Engineers.

Trials have been continued with a new class of bronzes richer in tin than had previously been thought to be practicable. During the year the oxide film, formed on the alloys when immersed in stagnant sea water and in sea water stirred by nitrogen, air, or oxygen, has been studied. It has been shown that very resistant films are formed and that the corrosion resistance of the alloys can be increased by pre-treatment with an oxide film. A number of new, complex bronzes containing tin have been selected for further corrosion tests in sea water. It is stated that these alloys are known, from previous work, to have satisfactory mechanical and working properties for the production of condenser tubes, and their compositions are such as to suggest that they will form the type of oxide film which confers resistance to corrosion. These experiments, however, are in the early stages.

As has been the case with most research institutions, the war has affected the work of the Council to some considerable extent. Early in 1939 a new plan of research was put into operation. Thirty-nine definite research projects were defined and suitably allocated, priority being given to selected projects. On the outbreak of the war, however, this plan was revised and it was decided to hold many of the original items in

DISC TAMPING ROLLER.

MESSRS. THE PARSONS COMPANY, NEWTON, IOWA, U.S.A.



abeyance. Consequently, during the past few months, research has been concentrated on tin-plate for canned foods, bearing metals for aero and Diesel engines, and hot-dipping and electro-deposition of tin and tin alloys, these subjects being considered of immediate urgency. In this connection it may be stated that a process for producing a protective film on tin-plate has been found and is being thoroughly tested with canned foods; the results are said to be very encouraging so far. As stated in the report for 1938, and recorded in our columns at the time, the offices in the new headquarters in Fraser-road, Greenford, Middlesex, were occupied at the end of 1938. Subsequently, the equipment of the laboratories in the new headquarters building proceeded rapidly, and, by the end of April, 1939, they were in working order, although further equipment is still being installed. Consequent on the centralisation of all work at Greenford, certain changes in the organisation have been made, but Mr. J. Ireland has continued as director of commercial development. On the retirement of Mr. D. J. Macnaughtan, however, Dr. E. S. Hedges, who was previously scientific officer, was made responsible for research, and Mr. W. H. Tait, who was previously secretary, was placed in charge of technical development. Mr. A. W. Powley has been appointed secretary.

DISC TAMPING ROLLER FOR ROAD CONSOLIDATION.

THE compacting of road and other surfaces where the material has been filled in or deeply disturbed during construction has hitherto been largely effected by the well-known cylindrical roller. This, however, does not function with equal efficiency on all classes of material; for one thing, a continuous cylindrical roller may ride on two or more hard patches and exert little pressure on an area of softer material in the space between them. For this and other reasons, the sheep's-foot roller, *i.e.*, a cylinder studded closely with staggered radiating feet, is employed to a considerable extent in the United States, and to some degree in this country, for certain classes of fills. It is claimed, however, by the makers of the disc tamping roller shown in the illustration on this page, viz., Messrs. The Parsons Company, Newton, Iowa, U.S.A., that this roller gives surface results at least as satisfactory as those of the sheep's-foot roller, while it has a more deeply penetrating effect on the material. At first sight, the roller may appear from the illustration to be of the ordinary cylindrical type with a ballast box on the frame. Actually, however, the roller is made up of twelve equally-spaced discs, 4 ft. in diameter and 1¾ in. wide on the face. Each disc rotates independently of the others on a fixed axle, which is hollow to permit of grease lubrication through it to the journal of each disc. The cross-section of the discs, in conjunction with the spaces between them, results in a definite crushing action on large pieces of clay and other conglomerated material, and the broken pieces are compacted laterally as well as vertically. There is, in effect, a kneading action on all classes of loose material. The independent rotation of the discs ensures uniformity of effect, particularly when curves are being negotiated, the skidding effect of a wide plain roller as it makes a turn being avoided.

As regards construction of the disc tamping roller, the illustration is more or less self-explanatory. The frame is formed from channels and angles with a yoke-bar in front and suitable cross-bracing. The side members are hung on the axles. A rake, adjustable as to height, on the rear of the frame, provides a means of roughly levelling the material after each passage of the roller, should this be required. With some kinds of material or working conditions, no rake is necessary, in others the form of the rake can be varied to suit. The roller is made in two weights, viz., 5 tons and 8 tons, without the ballast box. The actual contact pressure, without ballast, is 500 lb. per square inch with the 5-ton roller and 800 lb. per square inch with the 8-ton roller, the total width of the contacts being 21 in. It is a convention with some engineers in the United States, however, to calculate the pressure on the over-all width of the roller, whether that width is continuous or not. On this method then, with a total width of 5 ft. 7½ in., the theoretical pressure, without ballast, is 150 lb. per square inch for the 5-ton roller and 235 lb. per square inch for the 8-ton roller. The box will hold approximately 44 cub. ft. of ballast, so that, when filled, the total weight of the two rollers is increased by 3 tons, *i.e.*, the loaded weights are 8 tons and 11 tons, respectively. Both weights of roller have the same over-all dimensions, viz., 7 ft. 6 in. wide by 13 ft. long, the drawbar length being 7 ft. 9 in. The roller may be towed by either a wheeled or crawler-type tractor, a power of from 25 h.p. to 40 h.p. being required according to the type of material being consolidated.

THE APPLICATION OF ELECTRICITY IN BRITISH SHIPS.

(*Concluded from page* 289).

THE review on "Trends in the Application of Electricity in British Ships," by Mr. G. O. Watson, of which the first part appeared in our last week's issue, continues by pointing out that the use of the swinging frame in connection with direction-finding equipment is on the wane and is giving way to the fixed frame aerial and internal goniometer coils. A very ingenious form of the latter is arranged to have a light signal on a compass card giving the bearing of the radio beacon directly and obviating the necessity of using earphones to determine the minimum signal. This apparatus is claimed to be correct within 1 deg. when the vessel is out at sea, and uses stations within 20 miles. It is well known that in certain geographical positions the magnetic compass is unreliable. For instance, it is now essential for ships trading to Hudson Bay to be equipped with a gyro compass. One reason is the reduction in insurance rates to vessels so fitted, and another is that the proximity of the magnetic North Pole affects the standard compass so seriously that no reliance can be placed upon it. A sea-temperature recorder has been developed for the purpose of forecasting fog conditions. A difference of 1 deg. or 2 deg. in the surface temperature of the sea water may indicate the probability of fog, and a high degree of accuracy in temperature recording is, therefore, necessary. This particular equipment depends on the known relation between the resistance of pure platinum and its temperature. The thermometer consists of a glass tube upon which is wound a fine platinum wire having a resistance of 2,200 ohms at 32 deg. F. This is enclosed in a streamline casing in such a way that, when the whole is towed in the sea, water flows through the inside of the glass tube and ensures that the platinum winding quickly attains the true temperature, which is recorded by means of a Wheatstone bridge. The recorder must be installed in a position free from excessive variations of temperature, as, owing to the high sensitivity required, it has been impossible to eliminate errors due to changes of air temperature at the recording position. All large naval vessels carrying aeroplanes have their own meteorological offices on board for the purpose of supplying the aircraft personnel with weather forecasts; and the behaviour of wind is an important factor, a great deal being learned from the velocity and duration of gusts. An ingenious electrical method is now available for determining and recording the true direction and true velocity of the wind, making correction for the course and speed of the ship. Briefly stated, the method depends on a wind-speed generator in conjunction with compass-bearing and ship-speed measurements. A vector analyser, utilising alternating-current supplies, resolves the resultant "wind as felt" into its two component vectors, *i.e.*, that due to the course and speed of the ship and that due to true direction and true speed of the wind, these latter being recorded on a chart.

Following land practice, though not to the same extent, there is a trend towards more extensive use of gauges and instruments as an aid to the attainment of greater economy and improved performance of the boiler plant. With the increased use of water-tube boilers there is a demand for salinometers, and in this connection an unusual application is that adopted in the new French liner Pasteur. The salinometer is used to control the flow of water from an auxiliary tank into a main tank, and to cut off the flow when the concentration of salt in the auxiliary tank reaches 10 mg. of sodium chloride per litre. An alarm bell gives warning when the valves have operated. There is a tendency to employ Diesel-driven generators in conjunction with turbo-generators on steam-propelled vessels, so that during an overhaul, or while the vessel is lying up in port, the boilers can be completely shut down. Table I, on page 304, is an analysis of the electrical equipment of new vessels for which plans were dealt with by Lloyd's Register of Shipping during the years 1936, 1937, and 1938. A development more peculiar to the Continent is the application of dynamos driven from the propeller shaft and used with automatic voltage regulators.

A number of Diesel-engined trawlers have been equipped with electric trawl winches, varying in size up to 7½ tons pull, and have proved satisfactory as regards flexibility, convenience and safety. Probably there is no class of service which is more severe on electrical plant, since the ships operate in all weathers, often iced up in winter and with no skilled attention. There is a slowly growing demand for more flexible forms of speed control for such equipment as winches, capstans, etc., leading to the use of booster and reducer systems which are fitted with a modified form of Ward-Leonard control. Shipowners are realising more and more that higher speeds of lifting and lowering, combined with creeping speeds for breaking out cargo and for landing, are worth a little extra capital expenditure, since these features speed up cargo-handling and minimise the risk of damage. A development which has made considerable progress on the Continent is the use of electric deck cranes in place of winches. With regard to windlasses, there is a tendency in larger vessels to go in for split drives, *e.g.*, where a windlass would normally have a 100-h.p. motor for a single motor drive there will be two 100-h.p. motors, only one of which is in use at a time. Where the windlass is combined with capstans, both can be used for the latter, one for the starboard capstan and one for the port capstan. Also, they can clutch in the windlass to one or other of the motors, thus giving them the benefit of the windlass warp ends as well as both the capstans. In certain cases, it is possible to arrange that both motors can be clutched into the windlass so that extra heavy pulls can be obtained when necessary.

The chief progress in the refrigerating plant has been in the direction of auxiliary devices, such as recording apparatus, ozone generators, etc. Ozone-

generating devices are of considerable value with certain classes of cargo on account of the powerful oxidising properties of ozone, which instantly combines with and destroys any deleterious organic matter present in the air or in the foods or fabric, walls, etc., of the storage chamber. It is also useful as a de-odoriser for removing unpleasant smells, and in this respect is invaluable for removing the odour of one cargo before loading another of a different character which might be spoiled by contamination. For the correct control of refrigeration, accurate temperature recording at all parts of the chamber is necessary and electric distance thermometers meet this requirement. A comparatively new development of electrical instruments is in connection with gas analysis in refrigerated chambers. Recording and indicating instruments are available to indicate the percentage of both carbon dioxide and oxygen, the principle depending on the thermal conductivity of the gases. These are led through a metal tube about 4 in. long and about ¼ in. in diameter. A fine platinum wire is stretched along the central axis of the tube and is warmed by an electric current so that its temperature, and therefore its resistance, will depend upon the magnitude of the heating current and the thermal conductivity of the gas. Electric distance thermometers are also used for checking the temperatures in the chilled holds of fish trawlers, and it is of interest to note that special thermometers are obtainable which are so small that they can be inserted in the actual fish.

Although there have been isolated examples of the use of the multiple-motor starter, it has not made appreciable headway mainly on account of cost, in which is included installation cost and wiring. The systems comprise a master unit by means of which each of the motors in the engine room can be started, one at a time, by push-button control. After each motor is started and running it is connected to the "running" 'bus bars and the starting unit is then free for the next motor. In other cases, as in the Queen Mary and Mauretania, certain large motors have individual automatic starters grouped in a central control room in order to keep the engine room as free as possible.

The use of arc welding is continually extending, a small number of all-welded hulls having been built, but even in riveted hulls welded portions and structures are growing in number and the technique of shipbuilding and naval architecture is being continually modified to allow the builder to avail himself of advantages in weight and cost. In portable tools, the use of portable electric drills, grinders and reamers, is extending, a favourite tool being that operated by a high-frequency alternating-current supply. To keep weight within reasonable limits it is necessary to have a higher rotor speed than can be obtained with a frequency of 50 cycles per second, and these tools are operated at 180 cycles to 200 cycles per second, which gives a maximum rotor speed of about 12,000 r.p.m. Maintenance costs are low owing to the absence of commutators and the simplicity of the squirrel-cage rotor. A 75 per cent. reduction in power costs compared with those of compressed-air drills is claimed, largely on the score of efficiency, but partly as a result of better performance, *i.e.*, in the number of holes drilled or reamered per day.

Unfortunately, there has been no large electric propulsion equipment ordered or installed in the United Kingdom in recent years, orders, few in number, being confined to tugs, ferries and similar small craft. The most interesting of these is the Trinity House pilot cutter Vigia, which employs for this application an entirely new system of control. There are three 66-kW, 250-volt, 1,650-r.p.m. constant-voltage generators, coupled to Diesel engines and connected in parallel, and these operate a 240-shaft horse-power shunt-wound propulsion motor. Reversal is effected by reversing the propeller-motor field, a booster operating on the field and driven by the motor effectively limiting the peak loads to safe values during propeller acceleration and reversal. A feature of this equipment is the space occupied, which is considerably less in this particular instance than that required for any other form of drive. It is noteworthy that during the last three years there has been considerable activity in Germany in the application of electric propulsion. The technical directors of their leading shipping concerns state that they have examined the economics of the question and are satisfied that, for their purposes, electric propulsion is cheaper to operate than other types.

An interesting sociological sidelight is that German crews are required by law to have definite hours of leave while their ships are in port, and it is claimed that this is rendered possible for engine-room staffs by the adoption of multi-unit electric drive. With multi-engine Diesel-electric drive it is possible to shut down one engine without appreciable loss of speed and to proceed with adjustments and maintenance while the vessel is at sea. As already indicated, Germany has developed Diesel-electric drive with alternating-current transmission, coupled with alternating-current auxiliaries, development elsewhere having been confined to direct current, though it is understood that British firms are prepared to supply alternating-current equipments.

In the United States, the application of electric drives has slowed up, mainly owing to reductions in shipbuilding activity, but notable additions in recent times are those of the Atlantic Refining Company's new 18,000-ton welded tankers J. W. Van Dyke, E. J. Henry, and Robert H. Colley. They have turbo-electric drive, 625 lb. gauge steam pressure, and temperature 825 deg. F., or in the E. J. Henry 910 deg. F. The turbo-generator is rated at 4,500 kW, 2,300 volts, 3,600 r.p.m., and it can also supply auxiliaries, which, in this instance, are on the alternating-current system. In marine drives, rapid and frequent variations in load from no load to full load take place while manœuvring, and the period at no load may be a few seconds or several minutes, necessitating very close boiler control. In land installations, automatic combustion control is commonly practised, but not so at sea. These installations are noteworthy in that they are provided with complete automatic combustion control, including superheat control. Another foreign development of special interest is the application of electric slip couplings, originally developed in Sweden, but since made also in Holland and the United States. The use of slip couplings arises from the application of standardised medium-speed engines in conjunction with reduction gears. The usual combination is two or four Diesel engines coupled through slip couplings to a common gear wheel, the coupling providing for slight errors of alignment and damping out any torsional vibrations which might be transmitted to the gear teeth and shafting. The coupling is of simple mechanical construction having a fairly wide air gap of the order of 10 mm., one half comprising a multi-pole magnet system energised by direct current and the other half having a squirrel-cage winding. The slip is of low order, about 1 per cent. to 1·5 per cent., consequently the efficiency of transmission is very high, being of the order of 97 per cent. when excitation is taken into account.

There is a tendency with some owners to adopt pipe ventilation wherever possible for motors operating in oily atmospheres, the cooling air being obtained from a convenient ventilating trunk. Oily vapour causes trouble with commutation and insulation. There is scope for improvement in the insulation of motors for marine use, since, broadly speaking, present methods rely on the thoroughness of the impregnation to exclude oil and salt-laden atmospheres, and there is no practical test (other than length of service) which can be applied to impregnation. Substitutes for ordinary cotton-covered wire have been produced which are practically non-hygroscopic, and progress in this direction has been made, but there is need for further experience on this subject. Extended use has been made of electrolysers in recent years, particularly in liners, troop and hospital ships. The apparatus consists of a series of plates in a vat of sea water, the passing of a current through which produces sodium hypochlorite by freeing some of the chlorine content of the sea water. Sodium hypochlorite is a powerful disinfecting, deodorant and bleaching agent, which has been widely adopted on account of its low cost combined with its own non-poisonous and generally harmless nature. Five minutes' electrolysis will yield 6-7 gallons of sanitary fluid containing 2-2½ parts per 1,000 of available chlorine.

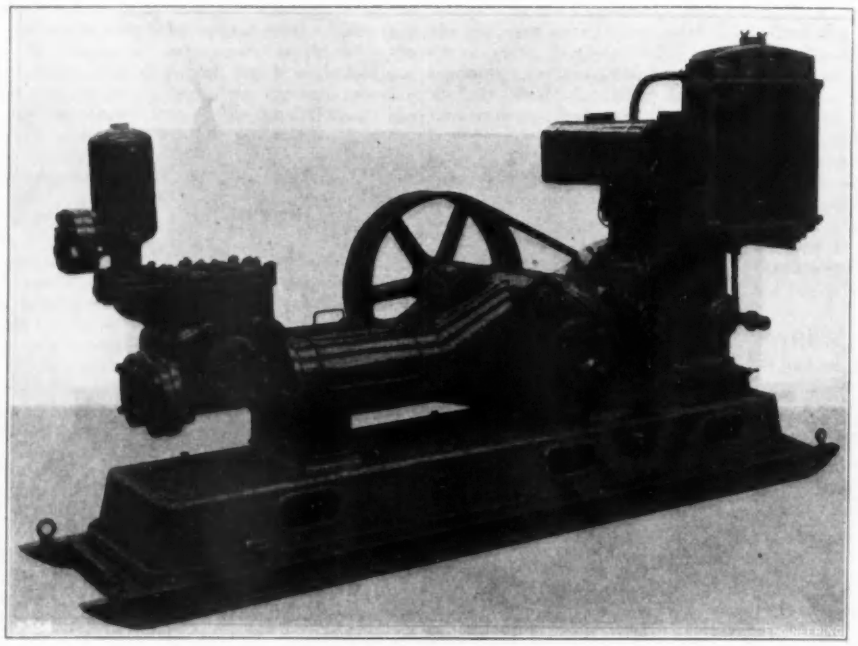
With regard to lighting, there is little to report, except a tendency towards simplicity instead of the rather ornate fittings in use a few years ago. More attention is being given to details of ventilation of large fittings, and in this connection natural ventilation has proved more suitable than forced ventilation by extractor fans, which have been found to cause an excessive accumulation of dust inside the fitting. Machinery spaces are more efficiently illuminated by lamps of high candle-power in suitable fittings, taking the place of small guarded pendants. Air conditioning in passenger and cargo vessels has made headway, and there has also been improvement in ventilation systems in general. Systems supplying hot and cold air, which may be regulated to suit individual requirements, are the general rule. Considerable attention has been given to the silencing of ventilating systems.

TABLE I. Analysis of Electrical Equipment of Ships.

Total Generator Capacity per Ship.	Number of Vessels.			Percentage of Total Number.			Aggregate kW.		
	1936.	1937.	1938.	1936.	1937.	1938.	1936.	1937.	1938.
15 kW and under ..	126	136	103	38·0	37·0	32·7	732	907	695
16 kW to 100 kW ..	121	116	131	36·2	31·7	41·6	4,404	4,745	4,407
100 kW to 200 kW ..	29	44	26	8·6	12·0	8·2	3,927	6,758	4,182
200 kW to 500 kW ..	45	46	29	13·4	12·5	9·2	14,654	16,010	9,134
Over 500 kW ..	13	24	26	3·8	6·6	8·2	15,157	40,258	36,538
Totals ..	334	366	315				38,874	68,678	54,956

DIESEL PUMPING SET FOR OIL-FIELD DUTY.

(*For Description see Opposite Page*).



GEARING FOR TWO-SPEED LIFTS.

CONSTRUCTED BY MESSRS. THE EXPRESS LIFT COMPANY, LIMITED, NORTHAMPTON.

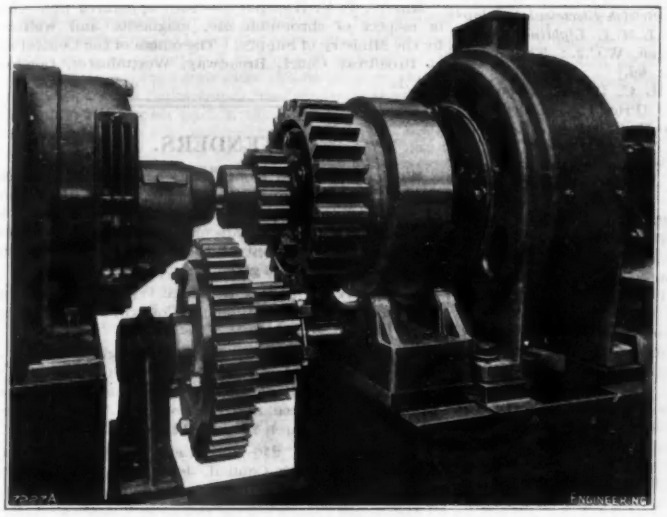


FIG. 1.

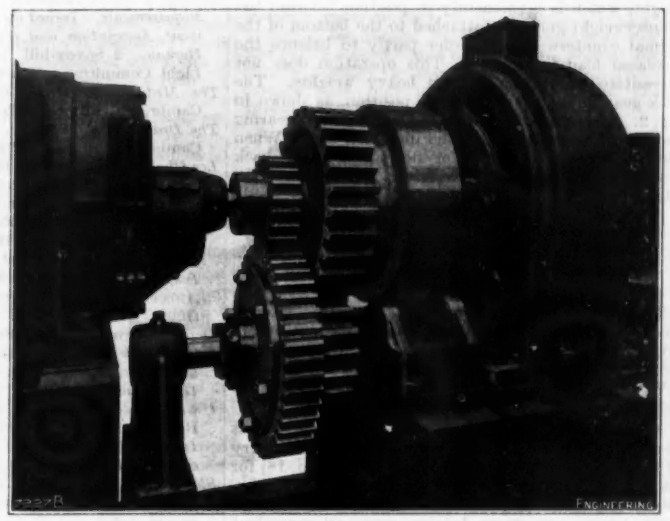


FIG. 2.

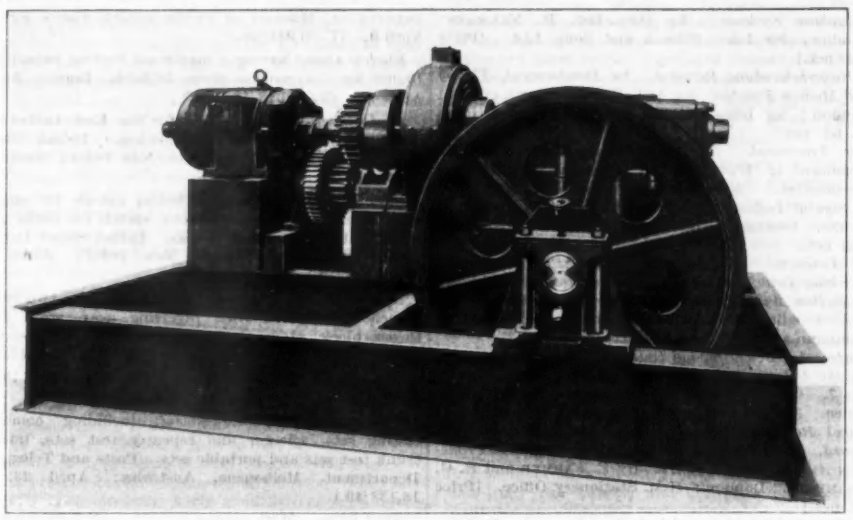


FIG. 3.

In switchboard construction there is a notable tendency to dispense with slate and marble and to use synthetic materials, which are more constant and reliable in quality. Systems of preferential circuits with selective tripping have been perfected and are more extensively used. They ensure that essential motors are retained in service and less important circuits cut out in the event of the generators becoming overloaded. The provision of means for fire protection and extinction has become more general, being almost universal in passenger and large cargo ships. Means for extinction include sprinkler systems, carbon-dioxide and foam generators, combined with detectors giving audible warning of the presence of smoke or excessive heat. A further safeguard provided in many instances is so to arrange all feeders supplying ventilating fans and heaters that they can be switched off from the bridge, thus ensuring that in the event of a fire these systems in any particular section of the ship can be shut down immediately. Electric lifts are extensively used, a large passenger ship frequently having seven or eight.

Several large electrically-driven scavenging blowers for Diesel engines have been supplied. Those for the Athlone Castle, Stirling Castle and Capetown Castle are rated at 590 brake horse-power, 220 volts, and 2,800 r.p.m., and are capable of supplying 31,100 cub. ft. of free air per minute at 3·4 lb. per square inch pressure. For the three Sulzer 12-cylinder two-stroke engines, each of 12,500 shaft horse-power at 145 r.p.m. to drive the passenger ship Oranje, the scavenging blowers are each driven by two 500-kW direct-current motors.

DIESEL PUMPING SETS FOR OIL-FIELD DUTY.

DURING the past year, a number of portable Diesel pumping sets have been supplied to the Burmah Oil Company by Messrs. John Fowler and Company (Leeds), Limited, Leeds, for general service in the company's oil-fields in India and Burmah. Among these were pumping sets for pumping fuel oil, one of which is illustrated by the photograph reproduced on the opposite page. In view of the type of duty which they have to perform, the sets have been designed as complete self-contained units, capable of operation on any site without specially prepared foundations and under arduous conditions, and also quickly transportable to any given locality. Each set consists of a Diesel engine driving a horizontal quadruple-acting pump through Texrope drive. The two units are mounted on a combination cast-iron baseplate, as shown. The engine is of the twin-cylinder Fowler-Sanders type, rated at 12 brake horse-power at 1,000 r.p.m., and incorporating the firm's two-way swirl combustion chamber. This engine, which is similar in general construction to the marine model described in ENGINEERING, vol. 148, page 323 (1939), is built essentially for heavy-duty work, and is of robust construction throughout, the cylinder block and crankcase being cast in one piece and the counter-balanced crankshaft being inserted endways. The base of the crankcase forms the lubricating-oil sump. Removable cylinder liners of the wet type are fitted, while the cylinder head carries overhead type valves. Careful attention has been given to dust-proofing, and the engine is of the totally-enclosed type, having all moving parts, including the C.A.V. fuel-injection pump, protected by oil-tight dust-proof covers. These covers are, however, easily removable, so that accessibility is unimpaired. A further protection against dust-laden atmosphere is provided by the fitting of an oil-wash type air cleaner to the air inlet to the cylinders. Radiator cooling is employed, a radiator of tropical capacity being mounted directly on the engine. A fuel tank of sufficient capacity for seven hours' running at full load is also mounted on the engine. Starting is by hand, a patented decompressor gear being incorporated.

Mounted on the same baseplate, as already mentioned, and driven by Tex-rope drive through a centrifugal clutch, is a horizontal quadruple-acting duplex power pump manufactured by Messrs. Joseph Evans and Sons (Wolverhampton), Limited, suitable for handling fuel oil. The pump has barrels of 1¾-in. diameter, the stroke being 5 in., and the crankshaft speed is 70 r.p.m., with a countershaft speed of 280 r.p.m. Both the inlet and outlet branches are of 2 in. diameter, and the pump is fitted with an air vessel, pressure gauge, and suction and discharge valves of the flanged full-way type. The baseplate is mounted on special steel skids, as shown, to facilitate transport, and the set forms a compact self-contained unit, which can be quickly brought into service on any desired location, an essential part of the service for which it has been designed. The Burmah Oil Company have also taken delivery of similar sets, designed and built by Messrs. Fowler's, but intended for water-pumping service. The general design of these water-pumping sets follows the lines of the fuel-oil sets described above, but the modifications necessary on the pumps for the handling of fuel oil are omitted. These sets are also fitted with steel skids and designed as portable self-contained units.

GEARING FOR TWO-SPEED LIFTS.

THE design of a goods lift which has normally to handle light, or comparatively light, loads at fairly high speeds, but may occasionally be required to deal with an exceptionally heavy load, offers a problem for which in recent times it has been increasingly necessary to provide a solution. It is clearly, for instance, uneconomical to install, say, a two-ton lift which rarely carries loads exceeding half a ton unless it can be arranged to do so at a considerably higher speed. Messrs. The Express Lift Company, Limited, Abbey Works, Northampton, have, therefore, designed a special form of worm-reduction gearing for this purpose, the appearance of which will be clear from Fig. 3. This incorporates double-reduction back gearing, which enables heavier loads than normal to be lifted when occasion arises, with, of course, a proportionate decrease in the lifting speed. The ratio of the spur gearing is usually, although not necessarily, 4 to 1, so that a lift which normally raises loads of one ton at a speed of 120 feet per minute could occasionally raise loads of two tons at a speed of 30 feet per minute. The cage safety gear, lifting ropes and

guides are all suitably designed for a lifting capacity equal to that of the heaviest load.

In normal operation the back gearing is disconnected, as shown in Fig. 1, and the motor drives directly through the worm reduction gearing. When it is necessary to raise the heavier load, the cage is first taken to the top floor and an additional counterweight, which is permanently in position between the counterweight guides, is attached to the bottom of the normal counterweight in order partly to balance the increased load in the car. This operation does not necessitate the lifting of any heavy weights. The back gearing is then adjusted in position, as shown in Fig. 2. The motor now drives through the spur gearing and all is ready for raising the increased load. When the lift is required again for normal use, the back gearing is returned to its original position and the additional counterweight disconnected.

BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, and, unless otherwise stated, the price is 2*s.* net, or 2*s.* 2*d.* including postage.

Fluorescent and Phosphorescent Paint.—At the request of the Air-Raid Precautions Department of the Ministry of Home Security, a specification (BS/ARP No. 18) for fluorescent and phosphorescent paint for A.R.P. purposes, has been prepared and issued. It concerns paints having a maximum brightness of 0·01 equivalent foot-candle, and a method of testing brightness is included. It is realised, however, that the measurement of brightness of the order of 0·0001 equivalent foot-candle by the method indicated may be difficult for laboratories not specially equipped for this work, and the committee responsible for the specification is, therefore, endeavouring to provide a simple form of brightness test, which, when completed, will be issued as an addendum to the specification. A preliminary draft of this simple form of test is available for comment, on application by persons interested, although it must be understood that it cannot be regarded as a standard test until published as such. [Price 6*d.* net, or 8*d.* post free.]

War-Time Street Lighting.—Although the installation of the new form of street lighting is only just beginning in many parts of the country, a revised edition of the specification BS/ARP No. 37, which deals with war-time street lighting, has been issued. This version, however, does not modify the provisions of the original edition (dated December, 1939), but extends them in two main directions. The first addition relates to the inclusion of standard curves of light distribution for fittings intended for mounting heights between 9 ft. and 14 ft. (nominal mounting height 10 ft.) and for use where the spacing is less than 100 ft., but is not less than 50 ft. These fittings are designated "10 ft. SS" to distinguish them from the 10 ft. nominal mounting light fittings intended for spacings over 100 ft. The second addition constitutes an appendix in which are given notes on the design and testing of fittings purporting to comply with the specification. The notes deal generally with photometric measurements at very low candle-powers. [Price 6*d.* net, or 8*d.* post free.]

Testing of Incombustible Material Resistant to Incendiary Bombs.—With a view to minimising the dangers resulting from possible incendiary-bomb attacks of the enemy, active consideration has been given, by the A.R.P. Department of the Ministry of Home Security, to the development of materials which could be used in the attics and roof spaces of buildings so as to confine, and afford protection against, the incendiary effect of the bomb. In order to assist in the development of such materials, a test has been devised, by means of which the performance of materials under incendiary-bomb effect may be ascertained. This method of test, together with the results which should be expected from a suitable material, have been made the subject of a standard in the A.R.P. series of specification and it is designated BS/ARP No. 27. It is further stated that the method of test is one which has been in use for some time at the testing station of the Fire Offices' Committee, and it is indicated that the tests will be made at the Elstree Testing Station on behalf of manufacturers who would like to have their materials examined. [Price 3*d.* post free.]

MAGNETIC-ORE FIELD IN INDIA.—It is stated in a recent issue of *Indian Engineering* that large deposits of magnetic iron are reported to have been discovered at and around Gore, near Daltonganj, Bihar Province, India.

BOOKS RECEIVED.

Records and Research in Engineering and Industrial Science. A Guide to the Production, Extraction, Integrating, Storekeeping, Circulation, and Translation of Technical Knowledge. By DR. J. E. HOLMSTROM. London: Chapman and Hall, Ltd. [Price 15*s.* net.]

Modern Factory Lighting. Including Special Wartime Requirements. Issued by the British Electrical Development Association and the E.L.M.A. Lighting Service Bureau. 2 Savoy-hill, London, W.C.2.: The Better Light Committee. [Price 8*s.* 6*d.*]

The Medieval Fenland. By H. C. DARBY. London: Cambridge University Press. [Price 12*s.* 6*d.* net.]

The Draining of the Fens. By H. C. DARBY. London: Cambridge University Press. [Price 21*s.* net.]

Les Chaleurs Spécifiques. By PROFESSOR EDMOND BRUN. 103 Boulevard Saint-Michel, Paris: Librairie Armand Colin. [Price 15 francs.]

Mines Department. Eighteenth Annual Report of the Secretary for Mines for the Year Ended 31st December, 1938 and the Thirty-First Annual Report of H.M. Chief Inspector of Mines for the Same Period. With a Statistical Appendix to Both Reports. London: H.M. Stationery Office. [Price 4*s.* net.]

Department of Scientific and Industrial Research. Quartz Oscillators and Their Applications. By DR. P. VIGOUREUX. London: H.M. Stationery Office. [Price 4*s.* 6*d.* net.]

United States Bureau of Labor Statistics. Serial No. R.1029. *Injury Experiment in the Iron and Steel Industry, 1937 and 1938.* Washington: Superintendent of Documents.

Short-Wave Radio. By J. H. REYNER. Second edition. London: Sir Isaac Pitman and Sons, Ltd. [Price 8*s.* 6*d.* net.]

Engineering Reorganisation. By J. J. GILLESPIE. London: Sir Isaac Pitman and Sons, Ltd. [Price 12*s.* 6*d.* net.]

Symmetrical Component Analysis of Unsymmetrical Polyphase Systems. By DIPL.-ING. R. NEUMANN. London: Sir Isaac Pitman and Sons, Ltd. [Price 21*s.* net.]

The Superheterodyne Receiver. Its Development, Theory and Modern Practice. By A. T. WITTS. Fourth edition. London: Sir Isaac Pitman and Sons, Ltd. [Price 3*s.* 6*d.* net.]

Water Treatment. A Comprehensive Treatise on the Treatment of Water for All Purposes and Effluents Purification. Sterilisation, Coagulation, Filtration, Storage of Industrial and Domestic Water. By C. V. JAMES. London: The Technical Press, Ltd. [Price 30*s.* net.]

Civil Defence. A Practical Manual Presenting with Working Drawings the Methods Required for Adequate Protection Against Aerial Attack. By C. W. GLOVER. Second edition, revised and enlarged. London: Chapman and Hall, Ltd. [Price 36*s.* net.]

Department of Scientific and Industrial Research. Methods for the Detection of Toxic Gases in Industry. Leaflet No. 7. *Carbon Monoxide.* London: H.M. Stationery Office. [Price 1*s.* 6*d.* net.]

Medical Research Council. Industrial Health Research Board. Report No. 84. *A Study of the Accident Proneness Among Motor Drivers.* By E. FARMER and E. G. CHAMBERS. London: H.M. Stationery Office. [Price 9*d.* net.]

Department of Scientific and Industrial Research. Building Research. Technical Paper No. 21. *Studies in Reinforced Concrete.* IV. *Further Investigations on the Creep or Flow of Concrete Under Load.* By DRS. W. H. GLANVILLE and F. G. THOMAS. London: H.M. Stationery Office. [Price 1*s.* net.]

Government of Bengal. Public Health Department. Engineering Branch. Twenty-Sixth Annual Report of the Chief Engineer, Public Health Department, Bengal, for the Year Ending 31st December, 1938. Alipore, Bengal: Superintendent, Government Printing, Bengal Government Press. [Price 8 annas, or 10*d.*]

Telephony. A Detailed Exposition of the Telephone System of the British Post Office. By T. E. HERBERT and W. S. PROCTER. Supplement to Volume II. London: Sir Isaac Pitman and Sons, Ltd. [Price 3*s.* 6*d.* net.]

TROLLEY OMNIBUSES IN YORKSHIRE.—A short time ago the Rotherham Corporation placed an order with Messrs. Sunbeam Commercial Vehicles, Limited, Moorfield Works, Wolverhampton, for a fleet of Sunbeam-B.T.H. six-wheel trolley omnibus chassis. Another Yorkshire transport authority, the Tees-side Railless Traction Board, which was one of the earliest undertakings to operate trolley 'buses in this country, has now placed an order with the Sunbeam Company. Both the Rotherham Corporation and the Tees-side Board use trolley 'buses exclusively of the single-deck type. A large proportion of the vehicles in the Rotherham fleet have six-wheel chassis, the Sunbeam-B.T.H. chassis now under construction for this undertaking being of the latest M.S. 2C six-wheel design. The bodies will have seating accommodation for 40 passengers.

PERSONAL.

MR. O. FRANCIS has been appointed private secretary to Mr. Geoffrey Lloyd, M.P., Secretary for Mines.

The Board of Trade has set up a Press section and MR. J. L. HENDERSON has been appointed Press officer in charge.

MR. W. T. V. HARMER has been appointed Controller in respect of chromium ore, magnesite and wolfram by the Ministry of Supply. The offices of the Control are at Broadway Court, Broadway, Westminster, London, S.W.1.

TENDERS.

WE have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

House-Service Cut-outs, insulated type, 1,600 sets, and 288 spare fuses. City Municipal Council, Johannesburg; April 10. (T. 16,812/40.)

Deep-Well Power Pump Heads and engines capable of pumping from a depth of 150 ft., with a capacity of between 1,000 gallons and 1,500 gallons of water per hour. Orange Free State Provincial Tender Board, Bloemfontein; March 29. (T. 16,837/40.)

Insulated Wire, 250-volt grade, flexible cable, and cab-tyre flex. City Council, Johannesburg; April 10. (T. 16,813/40.)

Galvanised Iron Work for Moroccan Telephone Administration. Office des Postes, des Télégraphes et des Téléphones, Rabat; April 2. (T. 16,977/40.)

Lorries, three, for transport of refuse. Municipalities Department, Ministry of Public Health, Cairo, Egypt; April 9. (T. 16,981/40.)

Electric Crane having a maximum loading capacity of 10,000 kg. Argentine State Oilfields, Buenos Aires; April 17. (T. 17,018/40.)

Steel Boiler Tubes required for the East Indian and Great Indian Peninsular Railways. Indian Stores Department, Mechanical Section, New Delhi; March 26. (T. 17,076/40.)

Steel Railway Springs, including spirals for engines and tenders, spiral bogie checks, spirals for brake gear, buffer plungers and draw hooks. Indian Stores Department, Engineering Branch, New Delhi; March 27. (T. 17,077/40.)

Marine Diesel Engines, two, 60-h.p., for two motor launches, complete with reversing gear, stern tube, thrust block, stern shaft and propeller. Ministry of Public Works, Cairo, Egypt; May 1. (T. 17,196/40.)

Artesian Wells, to be bored at Sedfa. Ministry of Public Health, Cairo, Egypt; May 4. (T. 17,199/40.)

Telephone-Testing Equipment, including combined testing sets, selector and repeater test sets, internal trunk test sets and portable sets. Posts and Telegraphs Department, Melbourne, Australia; April 23. (T. 16,438/40.)

Steel Plates. With reference to the call for tenders for steel plates noted on page 252, *ante*, we now learn that the South African Railways and Harbours, Johannesburg, have advanced the closing date from April 1 to March 26. (T. 16,630/40.)

Winch, capable of hauling a load of 200 tons, together with electric motor. Ports and Lighthouses Administration, Alexandria, Egypt; May 1. (T. 16,729/40.)

Telephone Parts, bell covers and other equipment to British Post Office specification. Post and Telegraph Department, Wellington, N.Z.; April 24. (T. 17,170/40.)

Bolts, coach, and engineers', black, and nuts, of various sizes. Post and Telegraph Department, Wellington, N.Z.; April 26. (T. 17,171/40.)

Pole Line Hardware, comprising galvanised heart thimbles, bow and "D" shackles, rigging screws with hooks and eyes, and pulley blocks. Post and Telegraph Department, Wellington, N.Z.; April 30. (T. 17,175/40.)

Arm Bolts of various sizes. Post and Telegraph Department, Wellington, N.Z.; May 2. (T. 17,183/40.)

Steel Pipes, straight, and specials. Municipal Water Department, Singapore; April 16. (T. 17,198/40.)

THE LEAD INDUSTRY IN CANADA.—The Canadian lead production during 1939 totalled 391,499,038 lb., valued at 12,375,000 dols., a decrease of 7 per cent. in quantity and of 12 per cent. in value, as compared with the 1938 output. Upwards of 97 per cent. of the total production emanated from mines in British Columbia, of which by far the largest producer is the Sullivan Mine of the Consolidated Mining and Smelting Company of Canada, Limited, at Trail.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The basis of production in the local steel and engineering trades is widening. Steel producers are accounting for larger outputs, but difficulty continues to be experienced in satisfying the needs of customers. Supplies of pig iron, hematites, and steel-making alloys have been well maintained. New records are being set up by the heavy-machinery and engineering trades, both in output and in the size and weight of products. In railway furnishings, shipbuilding requisites, and high-pressure boiler drums, business is brisk. Sheffield played a pioneer part in the development of trade in the last-named products, with the result that orders are on hand from various parts of the world. There is an improved call for heavy quarry machinery and mining plant. Furnace builders are exceptionally busy. The light engineering and tool trades are working at their full capacities; all types of engineers' small tools are in record demand.

South Yorkshire Coal Trade.—Considerable improvement has taken place in the past fortnight in the tonnage of coal being sent to industrial concerns. The house coal position is much easier, and small coal is in demand by electric power stations. Railway companies are placing orders more freely. Most types of coke are in demand. The export position shows slight improvement.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Conditions in the Scottish steel trade are practically unchanged this week and production is being maintained on an unprecedented high level. Despite the fact that the output of the works is at a maximum, it is barely sufficient to meet all calls and consumers are constantly pressing for further deliveries. Ship and boiler plates, and, in fact, all classes of heavy material are in urgent demand. A better supply of raw materials is now coming forward, and with the higher official price now prevailing for steel scrap, more has become available and the outlook has improved. There is a large demand for light plates, but in no case can early delivery be promised, while the makers of black steel sheets have also heavy order books. At the present time, most of the material on order is for home work of an urgent nature and little can be spared for export, with the result that licences are being granted rather sparingly. Prices are firm and are as follows:—Boiler plates, 13*l.* 8*s.* per ton; ship plates, 12*l.* 10*s.* 6*d.* per ton; sections, 12*l.* 8*s.* per ton; medium plates, under $\frac{5}{16}$ in. thick, weighing 6 lb. or more per square foot, 14*l.* per ton; weighing less than 6 lb. but not less than 4·81 lb. per square foot, 14*l.* 10*s.* per ton; black-steel sheets, No. 24 gauge, in 4-ton lots, 17*l.* 10*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, in 4-ton lots, 20*l.* per ton, all delivered at Glasgow stations.

Malleable-Iron Trade.—The malleable-iron makers in the West of Scotland have a fair amount of work on hand. The re-rollers of steel bars are still very busy as the present demand is exceedingly heavy. They have recently been receiving fairly good deliveries of semies. The following are to-day's market prices:—Crown bars, 12*l.* 17*s.* 6*d.* per ton; No. 3 bars, 12*l.* 10*s.* per ton; No. 4 bars, 12*l.* 15*s.* per ton; and re-rolled steel bars (tested), in 4-ton lots, 14*l.* 3*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—No change has taken place in the state of the Scottish pig-iron trade this week and makers are kept busy in supplying the heavy demand. While there are quite good stocks of iron-ore on hand, the current output of pig-iron is so large that steady shipments will be necessary to maintain production. The current prices are as follows:—Hematite, 6*l.* 7*s.* 6*d.* per ton; and basic iron, 5*l.* 4*s.* 6*d.* per ton, both delivered at the steelworks; foundry iron, No. 1, 5*l.* 15*s.* 6*d.* per ton, and No. 3, 5*l.* 12*s.* 6*d.* per ton, both on trucks at makers' yards.

THE KADENACY SYSTEM OF SCAVENGING; ERRATUM.—We regret that in the letter from Dr. G. F. Mucklow on "The Kadenacy System of Scavenging," published on page 286, *ante*, it was stated that the accompanying graph showed the observed rise of level in the suction tube when discharge occurred through pipes of $\frac{3}{32}$-in. diameter. This figure should have read $2\frac{1}{32}$-in. diameter.

THE PRODUCTION OF NATURAL GAS IN CANADA.—In 1939, the production of natural gas in Canada advanced by 5 per cent. as compared with 1938. The total, namely, 35,187 million cub. ft., constituted a record one for the industry. Natural gas is produced in New Brunswick, Ontario, Manitoba, Saskatchewan, Alberta and the North-West Territories. The provinces of Alberta and Ontario are the largest producers, the former having an output double that of the latter.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The demand for iron and steel is still on an unprecedented scale, but with all the producing plant in operation running at nearly full capacity, and the bulk of the output over the next few months required for the fulfilment of contracts already made, little new business is passing. The production is distributed as it becomes available, and rigid supervision of allocations is more necessary than ever to ensure adequate supplies of material for essential needs. The usual buyers have substantial orders to place for industrial purposes, but continued pressure for delivery for war time requirements leaves little tonnage available for ordinary commercial requirements.

Cleveland Iron Trade.—While conditions prevent the storage of foundry iron, consumers are receiving regular deliveries which are sufficient for their actual needs. The production of the well-known brands of Cleveland pig is still suspended, and there is no sign of a movement towards the resumption of output, but the small and irregular make of substitute iron suitable for foundry use continues and the tonnage arriving from the Midlands is maintained at a satisfactory rate. Second-hands can only deal in parcels of local foundry pig. Stabilised quotations for Cleveland qualities remain at the level of No. 3 description at 111*s.*, delivered within the Tees-side zone.

Hematite.—The resources of East Coast hematite makers are severely taxed to keep pace with the heavy demand. The large output is passing promptly into consumption, and stocks at makers' yards are low. An early enlargement of production by the kindling of additional furnaces is likely, as supplies of coke and ore are ample and one or two idle furnaces could be quickly prepared for use. Most of the supply is required for producers' own consuming works, but delivery calls, by buyers, against extensive contracts, are heavy. Fixed prices are based on No. 1 grade of hematite at 127*s.* 6*d.*, delivered to North of England areas.

Basic Iron.—There is no saleable basic iron, the nominal price of which remains at 104*s.* 6*d.*; all the output is needed for makers' steel-producing plants.

Foreign Ore.—Heavy imports of foreign ore have placed consumers in a satisfactory position as regards supplies.

Blast-Furnace Coke.—Local users of Durham blast-furnace coke have little occasion to buy and sellers have such extensive contracts to execute that they are disinclined to discuss new business, particularly as they are of the opinion that the position justifies rather higher prices than the recognised values, which are ruled by good medium qualities at 31*s.* 8*d.* at the ovens.

Manufactured Iron and Steel.—Imports of Continental semi-finished iron and steel are steadily maintained and home production of semies continues good, with the result that re-rollers are able to keep the mills actively employed. Finished-iron firms are fully engaged, except in the branch producing light castings, the demand for which has declined owing to inactivity in the building trade. Producers of finished steel have more work on hand than they can handle, and deliveries of shipbuilding requisites are exceeding expectations.

ALUMINIUM IN SHIPBUILDING.—According to information supplied by the Northern Aluminium Company, Limited, Banbury, Oxon, Messrs. Burmeister and Wain, Copenhagen, have made considerable use of aluminium and its alloys in the upper structure of the Fernplant, a motorship built by them for Messrs. Fearnley and Eger, Oslo, Norway. Fourteen tons of aluminium, it is stated, took the place of 40 tons of steel, and on her trials the speed of the vessel exceeded 15 knots, whereas the contract speed was 14 knots.

THE LATE MR. R. G. SCOTT.—It is with regret that we have learnt of the death in Edinburgh, on February 28, of Mr. Robert Grigor Scott, of Braeside, Loanhead, Midlothian. Mr. Scott, who was 69 years of age, was chairman and governing director of Messrs. MacTaggart, Scott and Company, Limited, hydraulic and general engineers, Station Ironworks, Loanhead. He was the eldest son of the late Mr. Robert Alexander Scott, accountant to the British Linen Bank, and received his education at Allan Glen's School. He obtained his early engineering training with Messrs. Lees, Anderson, Anderston, Glasgow; Messrs. Napier Brothers, Limited, Glasgow; and Messrs. Brown Brothers and Company, Limited, Edinburgh. In 1899, he collaborated with the late Mr. Hugh Holmes MacTaggart in the foundation of the firm bearing their names. During the war of 1914-18, he applied himself successfully to many problems which arose in connection with warships and submarines. His son, Mr. R. Lyon Scott, has now been appointed to succeed him as chairman and governing director of the company.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Middlesbrough Branch:* Saturday, March 23, 3 p.m., The Cleveland Technical Institution, Middlesbrough. Annual General Meeting and short paper competition. *Scottish Branch, Falkirk Section:* Friday, March 29, 6 p.m., The Temperance Café, Lint Riggs, Falkirk. Annual General Meeting.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, March 26, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Modern Steam Propelling Units and Their Possibilities for Cargo Steamers," by Dr. J.-B. O. Sneeden.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Scottish Centre:* Tuesday, March 26, 6.30 p.m., The Royal Technical College, George-street, Glasgow, C.1. Discussion on "Tariffs," to be opened by Mr. J. Eccles. *Institution:* Thursday, March 28, 6 p.m., Savoy-place, Victoria-embankment, W.C.2. Ordinary Meeting. "The Limitation of Transformer Noise," by Messrs. B. G. Churcher and A. J. King. *North Midland Centre:* Saturday, March 30, 2 p.m., The Hotel Metropole, King-street, Leeds. "A Critical Survey of American Metering Practice," by Mr. G. F. Shotter.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, March 29, 6 p.m., The Mining Institute, Newcastle-upon-Tyne. "Air Conditioning of Passenger and Cargo Spaces," by Mr. W. H. Glass.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, March 29, 6.30 p.m., 39, Victoria-street, Westminster, S.W.1. Ordinary Meeting. "Gas Producers as Applied to Transport Purposes," by Mr. Robert Lowe.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Concern over the increase in the control exercised over the coal export trade was expressed on the Welsh steam-coal market during the past week. It was complained that, in order to maintain deliveries to the more important directions, the authorities were exercising stricter control over the issuing of licences. As a result, some apprehension was felt by shippers that they would not be able to maintain deliveries to some of their customers, which would ultimately mean a loss of trade to the district. There were still some instances where productions were below the normal level, and as a result licences were only being issued by the authorities in respect of shipments consigned to the destinations set out on the priority list. Supplies for customers in markets outside these lists could not be readily secured. The whole matter was carefully considered at a meeting of local exporters at which the export officer for the area was present. In view of the present uncertainty of supplies, it has been agreed to extend loading hours and to make a variation in demurrage charges for Ministry of Shipping tonnage. There was again a keen demand on the market for all descriptions, but in view of the present position only a very little new business could be negotiated. Duff coals especially were in keen request, but stems for these kinds were well filled for some months to come and strong figures were secured for the occasional odd parcels that were available. Sized and large descriptions remained well placed with forward orders, while smalls were not easy to secure. Cokes were active, and patent fuel was busy.

The Iron and Steel Trade.—Active conditions ruled in the iron and steel and allied trades of South Wales and Monmouthshire last week. The demand for finished products was well sustained, while in view of the fact that rather more steel was available, the tin-plate works were busier.

THE ACTIVITIES OF THE NICKEL INDUSTRY IN 1939.—According to figures quoted by Mr. R. C. Stanley, President of the International Nickel Company of Canada, Limited, in his annual report for last year, the world's nickel consumption increased in 1939, attaining a new high record total which is estimated to be 256,000,000 lb. The corresponding totals, for 1938 and 1937, were 204,000,000 lb. and 240,000,000 lb., respectively. The Company's sales of nickel in all its forms, stated Mr. Stanley, totalled 210,194,135 lb. in 1939, a new high record and an increase of 45,815,890 lb. over the 1938 figure and of 2,493,192 lb. over the previous high-record total of 1937. Furthermore, the Company's sales of copper in 1939 reached a new peak total of 324,850,921 lb., against 292,129,727 lb. in 1938, and 291,880,403 lb. in 1937.

MECHANICAL ENGINEERING IN POWER STATIONS.

(*For Description, see Page* 317.)

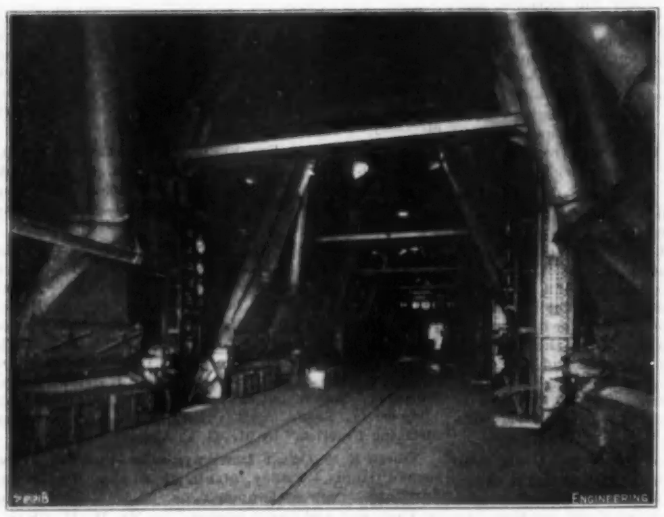


FIG. 13. BOILER HOUSE AT DEPTFORD WEST STATION.

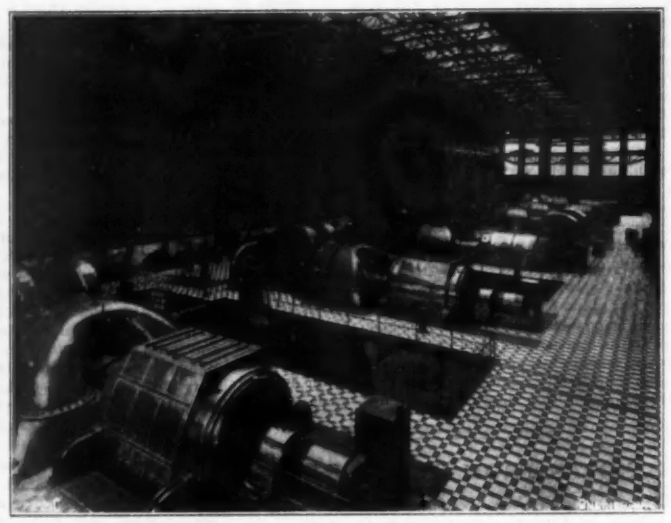


FIG. 14. TURBINE ROOM AT DEPTFORD WEST STATION.

THE PORT OF RANGOON.

IN Rangoon, recently, a joint Hindu-Moslem procession was held to mark the settlement of native differences. If this promise of a period of civil tranquillity is fulfilled, the expansive policy of the Port Commissioners, as exemplified in their 1938-9 annual report, is likely to be rewarded. The Rangoon rioting of July and September, 1938, took a toll of the Board's finances estimated at no less than Rs. 1½ lacs. Other factors contributing towards the fall of Rs. 1,20,781, represented in the total income of Rs. 69,76,000, have been the introduction of reduced foreshore landing charges and the continuation of certain rebates sanctioned since 1934. Even so, the year's total income exceeded expenditure by Rs. 8,48,033; and, although the sea-borne trade declined by 2 per cent. to 5,330,849 cargo tons, that portion which passed over the Commissioners' premises improved by 5 per cent. to 1,741,136 tons. Sea-going vessels to the number of 1,584, entering the port, represented a total of 4,311,002 net tons of shipping, and the rise of Rs. 61,000 in their dues is held to mark a return to normal in the volume of tonnage. Of the total of 1,584 calls, 626 were made by vessels of the British India Steam Navigation Company, the tonnage involved totalling nearly 1,722,000.

Frequent surveys conducted by the Marine Department recorded the erosion and the variations in soundings taking place in the Rangoon River. The dredger Cormorant, working on 194 days, removed 876,000 tons of sand and silt from the approach channels at a cost of 2 annas per ton. From the berths at wharves and jetties, 67,400 tons of spoil have been dredged at a cost of 9 annas 6 pies per ton, while the grab dredger has taken 76,033 tons more from the neighbourhood of jetties or behind pontoons. The major part of the Engineering Department's expenditure of Rs. 28,52,850 during the year was incurred in completing the new Brooking-street wharf, and little remained to be done there when His Excellency the Governor of Burma formally opened the wharf on March 31, 1939. This new two-berth reinforced-concrete wharf is 900 ft. in length, with an average width of 100 ft. Crane equipment on the wharf-head comprises eight 1½-ton electric cranes and one 40-ton travelling crane. A 10-ton electric transporter crane in the wharf yard will facilitate the handling of cargo to be stacked in the open. The wharf carries two single-storeyed transit sheds having a total floor area of 87,000 sq. ft. An open shed and four steel-frame godowns in the yard area provide additional storage for cargo. A system of trolley lines and turn-tables connects with the railway sidings in the yard, which are linked, in turn, with the Burma Railways' suburban line. The foundation work was done by contract, the remainder of the construction being carried through under departmental supervision. A substantial saving on the estimated cost of Rs. 52 lacs is anticipated. Following completion of this work, it was decided, in accordance with the Commissioners' programme of reconstruction, to begin the reconstruction of berths 1, 2 and 3 at the Sule Pagoda wharf. The first of three test cylinders was put down and load-tested to 230 tons, proved the satisfactory bearing capacity of the ground. This scheme, estimated to cost Rs. 72 lacs, is proceeding. During the year, the timber-built Phongyi-street lower jetty was replaced by a reinforced-concrete structure; and a new screw-pile jetty, 138 ft. long, was built at the Import Salt Depot out of second-hand piles and materials dismantled from the old Brooking-street wharf. The engineering workshops have been rebuilt and modernised, new equipment installed including an oil-filtration plant, and a number of machine tools.

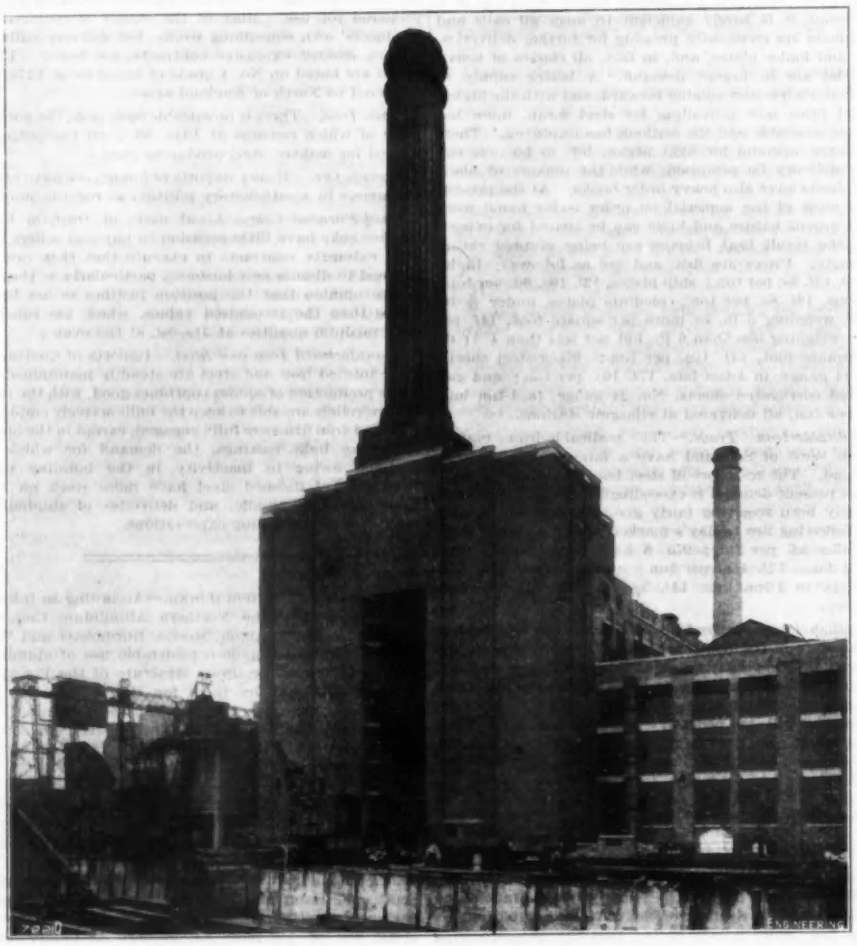


FIG. 15. EXTERIOR OF DEPTFORD WEST STATION.

THE ROYAL SOCIETY.—We are informed that the office of the Royal Society returned to the Society's apartments in Burlington House, London, W.1, on March 18, and that the library is to be re-opened. All communications should now be addressed to Burlington House.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and other publications bearing somewhat similar titles.

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ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages six words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns, of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of Publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, MARCH 22, 1940.

VOL. 149. No. 3871.

THE WAR IN THE AIR.

THE spectacular success of the Royal Air Force in all combats which have taken place over British home waters, taken in conjunction with the extensive flights over Germany, which are carried out practically without interference, and the overall results of the contests which have taken place on the Western Front, have not unnaturally led to the conclusion, in some quarters, that our machines and those who operate them are definitely superior to the corresponding units of the enemy forces. There is no need to traverse this idea in general terms, but it is well to remember that in warfare, as in other competitive activities, it is unwise to underestimate the prowess of an opponent. Without depreciating in any way the magnificent performance of the Fighter Command in home waters, it is fair to remember that the 40-odd German machines which have been brought down, without any loss on our side, were long-distance bombers, and that they were opposed by fighters. Admittedly, if this consideration is to have its full weight, it would be necessary that, when conditions were reversed and our bombers were opposed by fighters, the enemy should be able to claim the same result. This, clearly, they cannot do, as combats over the Heligoland Bight have shown. Our practically undisturbed flights over Germany also suggest that enemy fighters have learned to treat our bombers with respect.

Before taking these phenomena as complete evidence of the superiority of our machines and men, it is advisable to consider the possibility that they may be aspects of a considered policy. The strategy of the German higher command is its own secret, but it is permissible to draw some conclusions from its present proceedings. It is clear that efforts are being made to conserve the German air force. The reason for this must be a matter of pure speculation. It may be that petrol supplies are short and that some considerable development of Russian sources is awaited; it may be that shortage of certain materials is hampering production of new machines; it may be that six months of war has convinced the German command that their machines are inferior to those to which they are opposed, and that they are delaying matters pending the development of new types. Any, or all, of these suggested explanations may be wrong, but what is quite clear is that for some reason the German air force is being nursed and is not attempting to carry out the duties for which it may be presumed to have been built.

The chief evidence of the fact that the German air force either cannot, or is not permitted to, put up a fair fight is furnished by the really amazing way in which our long-distance bombers are allowed to fly over the length and breadth of Germany at their will, and by the very little opposition offered to our nightly security patrol over the German coast bases. The same tendency may be seen, however, in the offensive measures which the force is taking. Its chosen foe is an unarmed merchant ship or a fishing boat, and the invariable policy appears to be to retreat if any effective opposition appears on the scene. The machines never stop to fight. This policy of conservation may be determined by preparations for mass attacks of some kind, but in view of the claims which have been made for the German air force and of what is known of its magnitude, it would appear that this should not be sufficient explanation of the present relative inactivity.

Allowing every weight to the various considerations which can be raised, it is fair on the whole to draw the conclusion that our men and machines, in conjunction, are better than those to which they are opposed. This conclusion certainly appears to have been come to by Sir Kingsley Wood, the Secretary of State for Air, who has stated that he would sooner have 100 Wellingtons, or 100 Spitfires or Hurricanes, than a much larger number of their German counterparts. Considering the subject in its broad aspects, there are reasons to expect that British machines should be better than German. The social history of Germany over the last few years is in itself sufficient to explain a deterioration in German technical and scientific achievement. No country in which ability, energy and probity are sacrificed in the interests of the ruling party and in which a large proportion of the best brains are hounded abroad, or locked up, can maintain a leading position in the scientific world. The same sacrifice of ability to party has been in operation in Russia over a still longer period, with the result that what is claimed to be in point of numbers the largest air force in the world consists largely of copies of American designs five or more years old.

The general principles of aeroplane design are now generally understood, and the day has passed when a new type is the product of an individual genius. Each important stage in progress represents the culmination of a train of investigation carried out by a team of scientific and technical workers. What was possibly the most useful lesson that we learned in the last war was the value of research, and one of our most useful actions was the formation of the Department of Scientific and Industrial Research. It is largely to the activities of this Department that we owe our present position in the front rank of so many branches of scientific industry. This is not to say, or to imply, that all, or even the greater part, of the fructuous research work which has placed us in a leading position, for instance, in the aeronautical field, has been carried out in the establishments of the Department. The whole conception of this organisation, however, and particularly of the research associations which it fathers, has led to a widespread realisation of the basic part which research must play in progressive industry.

These considerations do not imply that there is no further need for the individual genius in the development of design. On the contrary, they

accentuate his necessity. It requires brains of the first order and a highly trained scientific imagination to take proper advantage of the mass of scientific data now available. The pioneer, however, who can see new possibilities, new combinations of known things and the best direction in which new work may be guided, requires the aid of a highly trained scientific staff to bring his ideas to fruition. No aeroplane designer in this country would wish to under-estimate in any way the ability and originality of Messerschmitt; they would be likely to agree, however, that unless he is backed by an adequate technical staff the full benefit of his genius will probably not be obtained. In a country in which the years of academic study have been curtailed, and the curriculum has been diluted by the introduction of courses devoted to party politics, the quality of that technical staff is not likely to remain high.

An illustration of the value, indeed of the essential nature, of this scientific team work was given by Sir Kingsley Wood in his statement to Parliament on March 7. He said that the long-nosed Blenheims had been given far better navigational qualities and something like a 50 per cent. increase in range; and that the top speed of the Spitfires had been increased by 10 per cent. Sir Kingsley did not enter into details, but it may be assumed that improvements of the type to which he was referring owe a good deal to engine development. The main point from our present point of view is that progress of this kind is made, in general, by groups of highly-trained scientific workers, and represents the culmination of intensive periods of detail investigation. It is not the result of a happy thought by a genius. If the possibility of this skilled team work is lacking, products of the highest class are not likely to be developed.

Although these various considerations lead to the conclusion that we may well be satisfied with our relative position in aeroplane design, that is no reason for any slackening in effort towards further improvement. Fortunately, there is no likelihood that any such feeling of false satisfaction will arise. One obvious direction in which the experience of the war up to the present time has suggested new problems to our designers has been indicated by the appearance of the Messerschmitt two-engine long-range fighter. So far, this machine has not rendered any important service to the enemy, but that its particular class, if it prove of value, will not be missing from our forces is made clear by the Air Minister's announcement that a number of new and powerful types of long-range fighters are now in production. No information has been given, or is likely to be given at the present time, as to whether these new types include two-engined machines. If they do, it is certain that the machines concerned will not be copies of the Messerschmitt 110 about which full information is available in this country. The problem of the advantages and disadvantages of two-engined fighters was given much consideration in this country long before the war. It is closely concerned with questions of manœuvrability against increased power and is related to similar questions which arise in naval affairs.

THE SHIPWRIGHTS' GUILDS IN FRANCE.

The art and craft of shipbuilding still awaits its historian. Slowly the materials are being gathered, but it is still the case that the exploits of ships and shipmen are more adequately recorded and scrupulously annotated than is the manner of ship construction, or the evolution and organisation of the industry that made large-scale construction possible. The immense scope of such a survey, embracing all Europe, as it must do to have any pretensions to completeness, might well daunt even a modern Gibbon. Apart from the technical detail, much of which is fundamental to the course of development, the wide sweep of the economic aspects is comparable with the initial plan of Buckle's *History of Civilisation*—with which, indeed, it has a great deal in common, for the history of civilisation is the history of transport, and transport by water was producing far-reaching effects while land transport in general was still almost parochial in its limitations. Sociology, too, must be regarded as an essential component study. Questions of "dilution" are commonly considered to be a recent complication in industry; but whence came the skilled labour for the great expansion of wooden shipbuilding that took place in England towards the close of the Napoleonic era, and for the rapid growth of iron shipbuilding that succeeded the "hungry 'forties," when so many scores of small yards went out of business and their staffs left the trade, never to return?

Gradually, as we have said, the available material is being sifted and collated, although progress is necessarily slow. In this country, much has been done by the Society for Nautical Research, supplemented by the largely unco-ordinated efforts of local enthusiasts in the shipbuilding centres. In France, where shipwrightry maintained for centuries a level unsurpassed elsewhere in Europe, the Académie de Marine has been equally industriously engaged. Some of the fruits of its researches have been published recently in the form of a volume containing four essays, the outcome of a contest proposed in 1937 by the Académie on the subject of "Les corporations de construction navale dans un port sous l'ancien régime."* Although competitions of this sort are, perhaps less in favour now than formerly, it can be said at once that any inducement which secures for permanent record a collection of historical and sociological studies of the interest and merit of these, needs no further justification. Each essay bears evidence of exhaustive research among contemporary documents relating to the selected ports of Honfleur, Fécamp, Nantes (considered together with Paimboeuf) and Marseilles, respectively. That it has proved possible to investigate conditions at Honfleur in more ample detail than at the other ports is due in no small measure to the extensive records in the possession of the Normand family, rendered available by M. Paul Augustin-Normand, who suggested the subject of the competition and himself has contributed an introduction to the volume. The period discussed covers approximately the two centuries between the States-General of 1614 and 1789. The latter date, corresponding to the final dissolution of the shipwrights' guilds and antedating by only a generation or so the advent of iron ships and steam propulsion, marks a rather more definite stage in the history of shipbuilding than does the former.

The pre-requisites to the building of wooden ships were relatively few, comprising merely the selection of a suitable site, sheltered from the sea, yet in direct communication with it; convenient access to raw materials, and the services of a body of skilled workers. Given the first two, the third could be expected to result from the gradual processes of local training and infiltration from other similar areas. It is significant that, in two of the four instances discussed in the essays, a degeneration in the suitability of the site, owing to silting and other causes, has led to the decline of the ancient port and the rise of newer centres across the estuaries at Havre and St. Nazaire. During the period under review, wood constituted by far the most important material of construction; but, although all four ports were within reach of local forests, the products of which were principally employed, it appears that the shipwrights of Honfleur, at any rate, made a regular practice of importing timber from the Scandinavian countries. Further, although much of the material for sails was manufactured locally, certain types of sailcloth came from Holland, while a favoured variety of pitch was brought from England. The use of wood for construction necessarily set limits to the permissible dimensions of ships, but advancing skill in design gradually refined their lines and progressively improved their sea-going qualities. Among the fleets of merchant ships sent forth from the ports of France during these two centuries were the numerous cod fishers, operating on the Newfoundland Banks, and many slave traders, making regular crossings of the South Atlantic. The stress of weather encountered on such voyages provided a searching test of the qualities of the ships and of the craftsmen who fashioned them. Thus, by its very nature, shipbuilding became a highly co-operative undertaking, leading almost inevitably to forms of mutual association among those engaged in it; and shipwrights' guilds accordingly flourished more or less consistently in all of the ports mentioned.

Like the trade guilds in England, these organisations were designed to safeguard the ideals and traditions of their members as craftsmen, and to protect their interests and privileges as citizens; but they were also semi-religious bodies, with their patron saints, their chapels in the local church, and their communal chests into which went fines and membership dues, and out of which were disbursed funds for philanthropic works among sick or aged members. Their power was such that, to follow a shipwright's calling in a particular locality, it was practically imperative to belong to the guild. They were governed by a small council of *jurés* or *prud'hommes*, elected from and by the general body of master craftsmen, and holding office for one or two years. Usually the *prud'hommes* were men of senior standing, and one of their duties was to inspect materials and workmanship on vessels under construction or repair; to act, in fact, in a similar capacity to that of the present-day ship surveyor. The status of master was attained in the usual manner, by way of the two lower grades of apprentice and journeyman. It was normally obligatory for a master shipwright to have under him at least one apprentice, who usually started his service between the ages of twelve and fifteen, and lived in the home of his master. His hours of work were from five in the morning to seven in the evening from April to September, and from dawn to dusk during the remainder of the year.

A poor boy could acquit his apprenticeship charges by continuing to work, without wages, for a stipulated period after the completion of his apprenticeship, the duration of which varied from two years to five years. Having satisfactorily completed his term, the apprentice became a journeyman and a wage-earner, normally remaining with the same master. To be himself admitted as a master, he was required, in most cases, to execute some stated piece of work to demonstrate his command of his craft. If this were approved, it only remained for him to pay the customary dues and to provide a suitable banquet for the existing masters, to celebrate his initiation. Although any master was deemed competent to undertake the construction of a ship, not all had the necessary capital; those who had not, joined the team engaged upon a new ship, or, alternatively, concentrated upon repair work.

Probably the most generally familiar survival of the guild idea at the present time is in the university system, under which the undergraduate frequents the company of masters in the several subjects for instructional purposes over a period of some years, to qualify for an examination, success in which confers graduate status and a Bachelor's degree. Further study, with perhaps the submission of a thesis, renders him eligible for a Master's degree. The degree ceremonies, especially at the older Universities, bear certain resemblances to the solemn initiation ceremonies of the ancient guilds.

The organisation of the shipwrights' guilds was not identical at each of the ports studied, nor did it remain unchanged throughout the period considered. Sometimes, for instance, the carpenters and caulkers were separately organised; at other times and in other places, they joined forces. At certain periods, when the Crown saw in them a means of curbing the power of the feudal landowners, the guilds received special signs of royal favour, and additional privileges; at other times, when the national coffers were depleted, they were exposed to less welcome consideration, and were subjected to fiscal exploitation. It is not easy to draw up a balance sheet, assessing the advantages and disadvantages of these guilds; though their social activities were beneficial in the main, their influence upon the craft tended rather to be conservative than progressive. Whether, if the Revolution had not put a term to their existence, they would have shown sufficient resilence to adapt themselves

* *Le Corporatisme Ancien de Construction Navale en France.* By A. Vintras, Jehan Banse, G. Decomble and Pierre Abbat. With an Introduction by Paul Augustin-Normand. Paris: Académie de Marine. [Price 100 fr.]

to the changing circumstances that were so soon to follow, must remain a matter for speculation. They did succeed in establishing a sense of fellowship and a community of interest that was largely lost in the unfettered individualism promoted by the Revolution. The consequences of that individualism, in the industrial field, were frequently undesirable, leading to disproportionate gain for some and undue exploitation of others, with little consideration for the general welfare. It was the abuse of child and female labour in the early days of the machine age that led eventually to the rise of the trade unions, the domestic legislation of which has been, perhaps, too exclusively devoted to the improvement of their members' economic status.

The aim of the guild system was, in part, economic, means being taken to restrict the number of masters on the active list, to avoid over-production with its attendant lowering of wages, and under-production, with a consequent rise in prices. It does not seem to have worked more smoothly or less oppressively than present-day expedients in times of real economic stress. Ironically enough, the shipwrights themselves were indirectly responsible for one of the most severe of these periods, in that they furnished the means to transport the Inca gold to Spain, the consequence of which was a severe and widespread monetary devaluation throughout Europe. Problems such as these may vary in the denomination of their terms, but in essentials they differ little between one era and another; so that studies of the type contained in this volume of the Académie de Marine, which aim at presenting an industrial system in its correct historical perspective, may well make a significant contribution to the harmonious and fruitful co-operation between the forces of capital and labour, the promotion and maintenance of which is one of the crucial problems of our own age.

NOTES.

The Trend of Unemployment.

The Annual Report of the Unemployment Insurance Statutory Committee for the year 1938-39, which was published last week, contains some interesting comments on the probable course of unemployment, both during and after the war. As regards the first of these periods, it is admitted that war renders it impossible to make any reasonable forecast of the future course of unemployment beyond the general statement that any great reduction is likely to be followed by a corresponding rise when hostilities cease. This unemployment, in fact, is likely to be severe, though it may not be immediate, and the rise may not be as great as in 1921 and 1922. Whatever is done, however, the transition from war to peace production cannot be accomplished without severe dislocation, though, in the opinion of the Committee, a period of eight years from now will cover both the war and a substantial depression thereafter. Though it may be possible to take action which will avoid the worst effects of the slump, it is pointed out that the number of men engaged in making armaments will be materially greater in proportion to the number of men in the fighting forces than it was between 1914 and 1918. This being so, it is satisfactory to learn that the Fund is in a sound condition and that, heavy as post-war claims are likely to be, they will not exceed or even approach the reserves that are nearly certain to be available. So strongly is this opinion held, in fact, that a large immediate reduction of debt has been recommended, a course which will both enable the debt charge to be reduced and set free a sum for immediate benefit to the families of the unemployed. This will be done without increasing the demands on contribution income and will enable borrowing to be effected more easily in future, should that course be desirable.

War Work for Small Engineering Firms.

To assist the smaller engineering firms in the country to obtain their fair share of war work, a problem about which a good deal has been written and spoken recently, the Minister of Transport has enlisted the aid of 110 Chambers of Commerce. "Offers of capacity" from these firms for munitions production are now to be examined by the Area Advisory Committees and Area Boards which are being set up, and it is hoped that the Chambers of Commerce will assist these bodies in an advisory capacity as far as they are able. The Area Boards consist of representatives of the Admiralty, Air Ministry, Ministry of Labour and National Service, and Ministry of Supply, and their duties are to secure co-ordination between all Government officials in the area in connection with the production of war stores, as well as to settle local difficulties likely to delay output, to transmit proposals for the exploitation of additional capacity in the area and to advise on matters relating to priority of contracts. It is possible that their membership will be increased by representatives of the Board of Trade in the interests of export trade. The Area Advisory Committees are composed of representatives of the Engineering Employers' Federation and the Trade Union Congress General Council, and their duties are to advise the Area Boards regarding efficient output and to assist in overcoming local difficulties. In addition, they survey the area with a view to increasing efficient production. The Committees have been supplied with details of various stores for which additional manufacturing capacity is needed, and which it is thought the smaller firms could make. It is the intention that the Committees shall make recommendations to the Area Boards regarding firms which they think could undertake this work, and it is hoped that in this way it will be possible to give more work to smaller industrial establishments. In addition to the Association of British Chambers of Commerce, the Federation of British Industries is co-operating with the Ministry of Supply in the work of bringing smaller firms into war production.

Twenty-One Years of Electrical Development.

The British Electrical Development Association celebrated its "coming of age" by a luncheon, which was held at the Savoy Hotel, London, on Friday, March 15. The President, Lord Lytton, was in the chair, and the principal guest was the Minister of Transport (the Rt. Hon. Euan Wallace, M.P.), though he was not present in person. The apparent paradox may be explained by saying that the Minister was suffering from influenza, but such are the combined resources of science and the Post Office that he was able to say a few words of welcome from his sick bed and to listen to what the other speakers in the room had to tell their audience. Proposing the toast of the "British Electrical Development Association," Mr. R. H. Bernays, Parliamentary Secretary of the Ministry of Transport, said that this body had had a most successful career. One example of its activities had been the "One Million Consumers" campaign, which had already enabled some 800,000 new consumers to be added to the mains. At the present time, "Business as usual" could not be adopted as a slogan, as it was 20 years ago, for we were fighting one of the most highly disciplined of nations and everything must be subordinated to winning the war in the shortest possible time. In this task the electrical industry was playing a vital part. It was the chief motive power in our munition factories, where it was essential for the production of aeroplanes, shells, guns and food. On the farm, where some 200 applications of electricity were possible, it could be no less useful in saving both time and money. While the black-out was essential as a protection against air attack, there was no reason why the Association should not encourage the reinstallation of an adequate standard of lighting in the house. In reply, the President said that only a visionary could have anticipated the developments that had taken place in the uses of electricity since the foundation of the Association. In 1919, only a million homes were using electricity and the output of the public generating stations was some three thousand million kilowatt-hours. To-day, nine million out of the twelve million houses in the country had an electric service and the output was some twenty-six thousand million kilowatt-hours. To begin with, the income of the Association was only 3,000*l*. To-day, double that sum was spent on a single campaign.

THE INSTITUTION OF NAVAL ARCHITECTS.

The annual general meeting of the Institution of Naval Architects, held in the lecture theatre of the Royal Society of Arts, John-street, W.C.2, as has been customary for many years, was this year of a purely formal nature. The meeting took place on Wednesday, March 13. There was no Presidential Address as such, and no papers were presented for oral discussion, though some had been circulated to members for written comments. One of these, "The Shipbuilding and Ship Repairing Industries after the War," by Sir Archibald Hurd, we commence to reprint on page 315 of this issue.

The chair was taken at the opening of the meeting by the President, the Rt. Hon. Viscount Stonehaven, P.C., G.C.M.G., who had consented to remain in office for the duration of the war. In expressing his pleasure at the invitation of the Council to continue his presidency, Lord Stonehaven said that he felt that changes of president should be made at intervals, in the same way as there were periodical changes in the Council, but he realised that, under present conditions, there were certain difficulties, and he was honoured to have been asked to remain in his present position. He thought that British naval architecture was contributing, not merely to the safety of the country, but to the prestige of Great Britain. Admiration of this country was not, in all things, world-wide, but he felt it was unqualified as far as naval architecture was concerned. The nation should be grateful for the naval architects it had had in the past, and for those who were continuing to maintain the splendid standard which had put us into a satisfactory naval position in the most critical times of the national life. Seeing the naval architect of the builders of the liner Queen Elizabeth, Mr. J. M. McNeill, present, he congratulated him on the vessel's magnificent performance on her recent voyage to New York. Lord Stonehaven then vacated the chair, and Sir Eustace H. T. d'Eyncourt, Bart, K.C.B., presided for the remainder of the meeting.

Report of Council.

The annual report of the Council for 1939 was then submitted to the meeting. It commenced with the announcement, received with unanimous applause, that Lord Stonehaven would continue as president for the duration of the war. The Council recorded their deep regret at the loss of those members who had passed away since the issue of the last Report, among whom were Mr. R. L. Scott and Mr. Summers Hunter, C.B.E., honorary vice-presidents; Engineer Vice-Admiral Sir Robert Dixon, K.C.B., D.Eng., vice-president; Mr. F. B. M. Harman and Mr. G. H. Kelson, members, who had long been associated with the Institution, having joined in 1887 and 1890, respectively; and Admiral of the Fleet Sir Roger R. C. Backhouse, G.C.B. G.C.V.O., associate. The total membership on December 31, 1939, was 2,576, this figure being identical with that for the corresponding date of 1938, though some relative changes had taken place, the roll of members having decreased, while that of associate-members and students had increased. The rearrangement of books in the Denny Library at the Institution's offices at 10, Upper Belgrave-street, London, S.W.1, had been completed, and facilities existed for postal borrowing of books by any member resident in Great Britain. The Council had decided that the usual Spring Meeting and Annual Dinner should not be held in 1940. They had given permission for the secretary, Mr. G. V. Boys, M.A., to be seconded to the Admiralty for war duty. His services were still available to the Institution, and members wishing to consult him might do so in writing. In his absence, Mr. P. J. Shilham was acting secretary. The audited accounts of the Institution and of the various funds administered by the Council were appended to the report, and these exhibited a satisfactory financial position.

The Institution was represented at the Jubilee meeting of the Society of the Friends and Supporters of the Hamburg Tank at Hamburg and Kiel in June, 1939, which meetings were followed by a visit to Berlin at the invitation of the Schiffbautechnische Gesellschaft and of the Lilienthal Gesellschaft für Luftfahrtforschung. The Institution was also

represented at the Congrés International des Ingénieurs Navals at Liége in August, 1939, held under the auspices of the Union Belge des Ingénieurs Navals. The Council recorded the thanks of the Institution for the hospitality enjoyed on these occasions. The Council appealed to members for continued support of the Tank Research Fund, in view of the importance of the work carried out at the William Froude Laboratory. Representatives of the Institution had been elected, since the issue of the *Transactions* for 1939, to six other bodies. A premium had been awarded to Mr. A. Nicholls, R.C.N.C., for his paper, "The All-Welded Hull Construction of H.M.S. Seagull." The Wakeham Prize was awarded to Mr. A. Emerson, B.Sc., for his paper "The Effect of Shape of Bow on Ship Resistance (Part II)." Thirty-two Ordinary National Certificates in Naval Architecture were awarded.

The Benevolent Fund Committee had continued to make grants to those who are in reduced circumstances and would welcome donations, and suggested the consideration of legacies, to assist in building up a reserve fund. Donations would also help towards the payment of grants now being made. Captain J. W. Harris, R.N.R., had been appointed to the Benevolent Fund Committee in place of the late Rear-Admiral Sir Douglas Brownrigg, Bart., C.B.; and Sir Alexander Gibb, G.B.E., C.B., Sir Robert Hadfield, Bart., F.R.S., and Engineer Rear-Admiral W. M. Whayman, C.B., C.B.E., had been re-elected to it. Grants had been made by the Institution to the Tank Research Fund; the Institution Benevolent Fund; the Ship Structure Panel of the Research Committee of the Institute of Welding; the British Electrical and Allied Industries Research Association; the Engineering Joint Examination Board; the Engineering Joint Council; the Joint Committee on Materials and their Testing; the Parliamentary Science Committee; and the Engineering Public Relations Committee. The Council had accepted, for administration by the Institution, the offer by the Wrought Light Alloys Development Association of a post-graduate scholarship in the application of light alloys to ship construction. The Martell Scholarship in Naval Architecture had been awarded to Mr. Norman W. Honey, of Sheerness Dockyard, and the Earl of Durham Prize to Mr. Peter E. Bish, of Chatham Dockyard. The report concluded with a list of the scholarships offered for competition in 1940. After the reading of the report, the honorary treasurer, Sir Philip H. Devitt, Bart., M.A., reviewed the audited accounts, the chief differences in which from previous accounts were due to the Institution having acquired a new home, which provided good accommodation, and to the improvements effected during the past year. The meeting unanimously adopted the report and accounts.

Election of Officers.

The following elections by the Council were then read out and unanimously ratified:—President, the Rt. Hon. Lord Stonehaven; vice-presidents, Sir Westcott Abell, K.B.E., the Rt. Hon. Viscount Weir, P.C., G.C.B., Professor P. A. Hillhouse, D.Sc., Sir John E. Thornycroft, K.B.E., Sir Harold Yarrow, Bart., C.B.E., Professor T. B. Abell, O.B.E., Dr. G. S. Baker, O.B.E., Sir Maurice E. Denny, Bart., C.B.E., Sir Stanley V. Goodall, K.C.B., O.B.E., Dr. J. Montgomerie, Mr. A. T. Wall, O.B.E., Sir Amos L. Ayre, O.B.E., and Dr. J. T. Batey; treasurer, Sir Philip H. Devitt, Bart.; acting treasurer, Sir Eustace H. T. d'Eyncourt, Bart., K.C.B. The results of the ballot for members of Council were then announced. These were as follows:—Vice-presidents, Professor C. J. Hawkes, O.B.E., Engineer Vice-Admiral Sir George Preece, K.C.B., and Mr. F. E. Rebbeck; Members of Council, Mr. J. L. Adam, Mr. John Austin, Mr. G. W. Barr, Mr. R. W. L. Gawn, Mr. A. J. Hendin, Mr. Summers Hunter, Mr. J. M. McNeill, M.C., LL.D., Mr. Henry Main, Mr. J. M. Ormston, M.B.E., Mr. H. B. Robin Rowell, and Mr. W. T. Williams; Associate Members of Council, Sir Robert Hadfield, Bart., F.R.S., Sir George Higgins, C.B.E., and Vice-Admiral Sir Cecil P. Talbot, K.B.E., C.B. After the election of 86 new members to various classes of membership, the meeting terminated with votes of thanks to Lord Stonehaven and Sir Eustace H. T. d'Eyncourt.

THE INSTITUTION OF MECHANICAL ENGINEERS.

Prior to the general meeting of the Institution of Mechanical Engineers, on Friday, March 15, at Storey's-gate, St. James's Park, London, S.W.1, a meeting of the members of the Benevolent Fund of the Institution, and of others interested, was held to consider the report of the Committee of Management for the year ending December 31, 1939. The chair was occupied by the President of the Institution, Mr. Asa Binns, who had consented to become the chairman of the Fund. The report showed not only a continued increase in the number of supporters but also an expansion of the resources of the Fund. The roll of membership comprised 2,236 names, as against 2,112 for the previous year, though, even with the increase, only 16·3 per cent. of the members of all grades of the Institution belonged to the Benevolent Fund. Contributions had been received, however, from 1,589 members who were not regular subscribers. The Committee made an earnest appeal to members to join the Benevolent Fund. The total revenue from all sources amounted to 2,704*l.*, as compared with 2,331*l.* for last year. This had left a balance of 98*l.* to be carried to capital account, whereas last year there had been a deficit of 66*l.*, which had necessitated drawing from the capital account. It should be realised, however, that, had not prohibitive conditions obtained towards the end of the year, the usual Committee meeting at that time would have had to disburse the balance among the several cases then awaiting consideration. As it was, the cases dealt with did not exceed those helped during the previous twelve months, viz., 58, though the average amount per grant showed a small increase. The Committee were gratified that this was possible in view of the fact that, for 18 years or so, the Fund had been able to make allowances only on a generally decreasing scale. The commendable practice, instituted last year, of giving some typical cases of hardships in the report was continued this year. Few members could be sufficiently sure of the future to ignore the implication of these cases and under such circumstances it was surprising to find that the response to the Silver Jubilee Appeal launched during the presidency of Mr. David Roberts had brought in, up to the present, a sum representing only about 4*s.* per head of the membership of the Institution. This meant that, of the sum originally aimed at, only just over 28 per cent. had, so far, been received. On the motion of the President, the report was adopted, and a resolution was passed for the transfer of a sum not exceeding 500*l.* from capital to income during 1940, should this be required to meet the increasing applications for assistance.

Three members of the Committee of Management, namely, the Rt. Hon. Lord Austin, K.B.E., LL.D., Mr. Charles Day, M.Sc.Tech., and Mr. W. A. Tookey, retired by rotation, and were not immediately eligible for re-election. To fill these vacancies, Mr. E. Bruce Ball, Mr. W. Littlejohn Philip, O.B.E., and Mr. G. Ethelbert Wolstenholme were elected. The honorary treasurer, Mr. W. O. Roberts; the honorary secretary, Mr. J. E. Montgomery, B.Sc. (Eng.); and the honorary auditor, Mr. Raymond Crane, F.C.A., retired by rotation and, being eligible, were re-elected. Mr. Frank W. White had been appointed Clerk to the Committee in March, 1939. Some discussion took place on various ways of increasing interest in the Fund, particularly as to the scheme suggested in the report, that representatives of the Fund should be appointed at each of the Institution Branch Centres, the intention of this step being the development of sustained and regular support in the provinces, in which originated most of the cases dealt with by the Committee.

The Thomas Lowe Gray Lecture.

The meeting of the Benevolent Fund was followed by a general meeting of the Institution, with the President, Mr. Asa Binns in the chair, the occasion being the twelfth Thomas Lowe Gray Lecture. After routine business had been transacted, the President recounted the origin and aims of the lecture and then called upon Professor A. L. Mellanby, D.Sc., LL.D., to deliver it on this occasion. The lecture, which was entitled "Fifty Years of Marine Engineering," will be reproduced in a subsequent issue. In accordance with precedent, no discussion took place after reading the Lecture. A vote of thanks was proposed by Mr. E. Bruce Ball, past-president, seconded by Dr. S. F. Dorey, Member of Council, and carried by acclamation.

METALS AS ENGINEERING MATERIALS.—III.

At the outset of the last of his series of three Cantor Lectures dealing with "Metals as Engineering Materials," delivered recently before the Royal Society of Arts, London, Dr. C. H. Desch, F.R.S., stated that iron, which in one form or another was the most important of structural metals, was very soft and weak in the pure state; on the Brinell scale, its hardness, namely, 48, was less than that of copper. That it could assume such different properties was due mainly to two peculiarities: its abnormal allotropic changes and its sensitiveness to the influence of carbon. Ferrite, the α modification of iron, which was stable at atmospheric temperatures, constituted almost the whole of wrought iron and of ingot iron. It could take certain elements into solid solution without losing its character, and the silicon steel used for transformers, for example, was a homogeneous silico-ferrite, identical in structure with the pure metal, and, like it, magnetic. On the other hand, ferrite could take only a very little carbon into solution (0·02 per cent. at room temperature and 0·07 per cent. near to 700 deg. C.), and that little had but a small hardening effect. At 910 deg. C., iron passed into the γ modification, having a crystal structure like that of copper, nickel, aluminium, and many of the ductile metals. This, however, had a considerable solid solubility for carbon, reaching 1·7 per cent. at 1,130 deg. C. At 1,388 deg. C., continued Dr. Desch, the structure reverted, most surprisingly, to that which the metal had at low temperatures, but now called, for convenience, δ iron, and all its properties were such that if plotted against the temperature, they lay on a prolongation of the α curve. The γ range was, so to speak, an episode in the thermal history of iron.

The elements which were able to form alloys with iron could be divided into two groups, according to their effects on this episodical γ range. One group "closed the γ loop," namely, additions of the element raised the $\alpha \rightarrow \gamma$ temperature and lowered the $\gamma \rightarrow \delta$ temperature, so that, with a sufficient addition, the two temperatures coincided, and, beyond that composition, the alloys consisted only of α and had no allotropic changes. In the absence of carbon, this was true of aluminium, silicon, titanium, phosphorus, vanadium, chromium, molybdenum and tungsten. Members of the other group widened the γ range, so that, with a sufficient addition, the alloys retained this structure permanently, or in some instances only changed over at very low temperatures, as on cooling in liquid air. In the presence of carbon the changes were naturally more complex. Carbon itself was one of the elements which widened the γ range, and the group included nickel, cobalt and copper, although the last could only be added in small proportions. Added elements had another effect besides that of altering the range of solubility of the several modifications of iron. They also retarded the allotropic changes, so that while no quenching, however rapid, would preserve the γ condition of iron when pure, a solid solution having the same structure, namely, austenite, could either be preserved unchanged on rapid cooling, or, if a change took place, it was only partial, so that intermediate structures were obtained. Martensite was such a structure, finding no place in the stable-phase diagram, but playing a most important part in the technical applications of steels.

Within the last few years, attention had been particularly directed to the rate of transformation of austenite into stable or metastable products during cooling. It was known that martensite was not a stage through which a steel passed during slow cooling, but that it was formed, with finite velocity, only when a certain comparatively low temperature, in the neighbourhood of 200 deg. C.,

was reached. The experiment had then been made of quenching a steel in the austenitic condition, not in cold water, but in a molten metal, and it was found that it would then remain soft and ductile for a long time, but that, on cooling from that temperature, even without sudden quenching, it at once became hard and then consisted of martensite of the typical kind. This experiment had been the starting point, not only of new methods of investigating the structural changes in steel, but also of important practical applications. A steel containing 1·6 per cent. of carbon was heated strongly to 1,150 deg. C., and was then plunged into a bath of molten metal at 160 deg. C. At that temperature a surface could be ground and polished, the structure proving it to be unchanged austenite. On allowing the temperature to fall, keeping the specimen under observation under the microscope, the formation of martensite crystals could be watched, owing to the fact that an expansion took place, so that each new crystal appeared in relief. The remarkable fact was found that each crystal made its appearance fully formed within a very small fraction of a second, and did not grow further, the transformation of neighbouring parts of the austenite going on until the whole had been converted.

The new method of investigation consisted in heating the steel under test to such a temperature that it was entirely in the condition of homogeneous austenite, cooling it very rapidly to some predetermined temperature, allowing the transformation, whatever it might be, to proceed isothermally, and then quenching it rapidly. Any austenite not transformed at the moment of quenching then became martensite and could be identified microscopically after the experiment. In this way, the rates of transformation of many steels at various temperatures had been measured. The process had found commercial application and was sometimes called "austempering." The steel was cooled in a bath at a pre-determined temperature and the transformation was allowed to continue at constant temperature. This evidently allowed of very perfect control, when the most suitable temperature of transformation had once been determined. It was, however, confined to objects so thin that the preliminary cooling through the range between 700 deg. and 500 deg. C. was sufficiently rapid to prevent the formation of pearlite, or one of its varieties.

The properties which might be obtained as the result of adding small quantities of alloying elements to a carbon steel were truly remarkable. The variety was so great that it would be useless to give many illustrations, but an example might be taken from Dr. H. J. Gough's account of aero-engine materials.* A steel containing 3 per cent. of nickel, 1 per cent. of chromium, 0·5 per cent. of molybdenum, and 0·2 per cent. of vanadium (the last-named metal being added to preserve a fine grain) would give, in the hardened and tempered condition, a proof stress of upwards of 60 tons per square inch, a tensile strength value of up to 75 tons per square inch, an elongation of over 16 per cent., and an Izod value of over 40 ft.-lb. Probably the highest mechanical properties that had yet been reached were given by a steel, also of the nickel-chromium-molybdenum-vanadium class, which, in the hardened and tempered condition, gave the remarkable figures of 149 tons to 153 tons per square inch tensile strength; from 9 per cent. to 10 per cent. elongation from 8 ft.-lb. to 12 ft.-lb. Izod value, and a fatigue range by the Wöhler test of $\pm$ 57 tons per square inch on plain bars and of $\pm$ 28·5 tons per square inch on notched specimens. Steel of such high strength, however, was somewhat sensitive to stress concentrations at fine cracks, and it must be remembered that its elastic modulus was no higher than that of a weaker steel.

When more than one phase was present, the texture of an alloy, namely, the arrangement in space of the constituents, profoundly affected its properties. A striking example was that of grey cast iron. This contained flakes of graphite, which served several useful purposes, but which constituted surfaces of weakness along which cracks might spread. By suitable control of melting conditions, the flakes might be reduced in size without altering their quantity and aggregated into small clusters which had far less weakening effect than in the coarsely graphitic form. In a similar manner, the distribution of ferrite and carbides in a given steel, the relative quantities remaining the same, might give rise to marked differences of properties, and the effect of heat treatment depended as much on control of the texture in this sense as on that of the degree of transformation. If the surface of a steel were hardened without altering the toughness of the core, a marked improvement of properties could be obtained. This could be done in several ways, and one, which was the most recent, was to apply cold working to the surface, by rolling, hammering with a rounded hammer or swaging hammers, or by the "cloudburst" method of showers of impinging steel balls. In this manner a superficial layer of cold-worked material was formed, and, what was perhaps also important, ultra-microscopic cracks were closed up.

The most interesting of the light alloys were those which underwent age-hardening. The essential condition that an alloy should be susceptible to age-hardening was that it should contain a constituent which could be brought into solid solution at a high temperature, but had a solubility which fell rapidly with the temperature. The constituent was retained in solid solution by quenching and was released, either spontaneously at atmospheric temperature, or on heating to a moderate degree. Many of these alloys in the heat-treated condition were comparable, in mechanical strength, with structural steels, while they remained susceptible to cold work, so that in the form of sheet, for example, high strengths could be obtained. The effects of age-hardening, however, were not always beneficial. The ageing of mild steel was a consequence of its normal composition. A low-carbon steel, which had been cooled rather rapidly through the range below 600 deg. C. after annealing, spontaneously hardened and lost ductility in the course of a few weeks' storage. This was attributed to the precipitation of the very small quantity of carbide held in solution in alpha iron. A more important effect was "strain-ageing." Mild steels, like other metals, were hardened by cold-working, but in their case a further increase in strength and loss in ductility were observed in the course of weeks after deformation. Such internal changes, on a scale too fine to be observed under the microscope, were among the most interesting effects demanding study in materials used for engineering.

The development known as "powder metallurgy," or as "metal ceramics," gave possibilities of making certain engineering parts with quite novel properties. In this process, the metals, instead of being cast into ingots or directly to shape, were used in the form of powder and compacted by pressure followed by heating. The method had long been employed for metals of very high melting point, such as platinum and tungsten. It was quite possible to melt even tungsten in an arc or high-frequency induction furnace; the difficulty was that there was no material which would serve for crucibles except carbon, which was out of the question on account of chemical reactions. For metals of lower melting point, the powder method could be employed to produce objects of accurate dimensions, as a substitute for die castings, but it was also valuable for making masses having any desired porosity. Porous bronze castings, made by compressing copper, tin, and graphite powders together and heating until sintered, were useful on account of their power of holding oil. It was possible to make a bearing of graduated composition in order to combine two qualities, that of giving good adhesion to the supporting steel while having a harder wearing surface.

Powder metallurgy was also used for the production of hard carbide masses used for cutting tools and dies, consisting of particles of tungsten, titanium, and other carbides, united by sintering with more fusible metals, mainly cobalt. For the balancing of flywheels, masses of a very heavy sintered material, originally devised for radium containers, and made up of tungsten powder sintered with copper and nickel, had found an unexpected application.

* *Jl. Royal Aero. Soc.* vol. 42, page 921 (1938).

THE INSTITUTE OF MARINE ENGINEERS.

THE fifty-first annual general meeting of the Institute of Marine Engineers was held on Friday, March 15, at the Connaught Rooms, London, W.C.2, the President, Sir Percy E. Bates, Bart., G.B.E., occupying the chair. After the transaction of the formal business, the secretary, Mr. B. C. Curling, presented the Report for the year ending December 31, 1939, of which a summary is here given.

The Report commenced with a note on the difficulties created by war-time conditions in the development and maintenance of the activities of the Institute, drawing attention to the fact that its sea-going members in the Royal and Merchant Navies had to carry out their duties in circumstances perhaps the most acutely hazardous and nerve-wracking of those of all combatants. Although present conditions militated against the recruitment of new members, the roll showed a net increase of 76 names, the total on December 31, 1939, being 4,186, the full members forming the largest class. To maintain the membership at its present strength, under existing abnormal circumstances, members were urged to co-operate in ensuring an adequate number of suitably qualified candidates. The losses by death in the period covered by the report numbered 40, several deaths being due to enemy action. Other losses included individuals who would be remembered for particular service to the Institute, namely, Engineer Vice-Admiral Sir Robert B. Dixon, K.C.B., past-president; Mr. Summers Hunter, C.B.E., past-president; Engineer Vice-Admiral Sir Henry J. Oram, K.C.B., F.R.S., honorary member; and Mr. Llewelyn Roberts, C.B.E., vice-president. The Council, on a unanimous resolution, invited Sir Percy Bates to accept nomination for a second year of office as President, and his consent had given much satisfaction. The following appointments of vice-presidents had been made to fill casual vacancies: London, Mr. G. J. Isaac; Sunderland, Mr. F. H. Reid, B.Sc., Wh.Ex.; Calcutta, Mr. C. S. McCaskie; Merchant Navy, Mr. W. C. Sutcliffe; Royal Navy, Engineer Rear-Admiral F. R. G. Turner. The result of the poll on the resolution to increase membership subscriptions was in the ratio of 9·6 to 1 for the resolution, and the by-laws had been amended accordingly and members notified.

The lectures and social functions for the 1939-1940 session had been cancelled on the outbreak of hostilities, and the committee meetings had been temporarily suspended, though these were now functioning normally and meetings were held to deal with business as it arose. Five papers had been read and discussed in the first part of the session and six papers, not read, had later been published in the *Transactions*. The Denny Gold Medal had been awarded to Mr. C. C. Pounder for his paper entitled "Some Recent Diesel Installations and their Characteristics." Institute Silver Medals had been awarded to Dr. T. Swinden and Mr. F. B. Cawley, M.Met., for their paper entitled "The Acid Bessemer Process of Steel Making." In the Essay Competition, a Murdoch and Robertson Prize had been awarded to Mr. R. A. Collacott for his essay entitled "Automatic Control Apparatus in Refrigerating Plants"; a partial Stephen Award had been gained by Mr. G. A. Day for his essay entitled "Electricity in Oil Carrying Vessels"; and the Akroyd Stuart Award had been gained by Mr. S. N. Mukerji, M.Sc., of Calcutta. The Institute Medal for the candidate attaining the highest position in the Extra First Class Engineers' Certificate Examination had been awarded, after consultation with the Ministry of Shipping, to Mr. J. E. Rundle. Since the institution of the scheme of endorsement of National Certificates with special reference to marine engineering, 27 Ordinary Certificates and seven Higher Certificates had been so endorsed and issued. It was considered that the scheme should have the effect of stimulating the recruitment of junior engineer officers for the Merchant Navy. In this connection, representations had been made to the Ministry of Shipping on the diversion of junior engineers from this service by conscription of marine-engineer apprentices to the Army before their four years' training had been completed.

Other sections of the Report dealt with the Junior Section meetings; the Education Group; Guild of Benevolence; representation on outside bodies; and the Central Register for National Service. The section dealing with the library recorded that both library and the reading room were still open at the Institute's headquarters, though the offices had been removed to 73, Amersham-road, High Wycombe. The report of the auditors, the balance sheet and sundry accounts were appended to the main report. The gross revenue for the year ended December 31, 1939, was 8,070*l.*, the balance of revenue over expenditure for this period being 515*l.*, as compared with 637*l.* for the preceding year. A financial statement by the honorary treasurer followed the reading of the annual report, after which both report and accounts were unanimously adopted. In response to a vote of thanks to the President, proposed by Mr. A. F. C. Timpson, M.B.E., chairman of Council, Sir Percy Bates, after some comments on the difficulties of carrying on a technical organisation in such times as the present, said that he had had the honour of holding an honorary commission in the Royal Naval Reserve and had been struck by the fact that, compared with the deck officers, few engineer officers of the Merchant Navy joined the reserve in times of peace. As a result, there had been some little difficulty in arranging for temporary commissions for mercantile marine engineers serving in what are now His Majesty's ships. That difficulty would hardly have arisen if marine engineers as a body had interested themselves in the Royal Naval Reserve prior to the outbreak of war. He was particularly interested in that side of the profession.

The general meeting was followed by a luncheon, at which some 270 members and guests were present, the latter including Sir John Gilmour, Minister of Shipping. Sir John, in the course of proposing a toast, acknowledged the help that politicians received from technical men, spoke feelingly of the strain and anxiety suffered by the marine engineer in times of war. It was immensely difficult to carry on in the bowels of a ship without knowledge of what was likely to happen, but he was sure that engineers as a whole retained their skill and courage in such trying circumstances. He took the opportunity of congratulating Sir Percy Bates on the successful voyage of the Cunard-White Star liner Queen Elizabeth, without having undergone the usual trials and tests. The performance was to the credit of those who designed and built such vessels, as well as those who manned them. Sir Percy, in the course of his reply, observed that the Minister of Shipping was the largest user of marine horse-power in the world in the Merchant Navy, the Royal Navy probably coming next. Co-operation between the two services to-day was such that essential technical information obtained from experience was freely interchanged. H.M. ships were built, for one thing, to operate under extreme conditions for short periods. In the Mercantile Marine ships were regarded more from the point of view of reliability of service rather than in terms of speed.

It was very satisfactory to note that the First Lord of the Admiralty has recently stated that naval vessels were standing up to their arduous job in a surprising way. He would suggest that this showed that naval and mercantile marine practice were coming together. He hoped the two "Queen" ships would ultimately break the record set up by the Aquitania in the number of round voyages made in six months. He appreciated the reference to the performance of the Queen Elizabeth, and added that the company's superintending engineer, Mr. Austin, had stated that while the vessel's speed could be taken at about 25 knots, if an enemy submarine were in the vicinity a bit over 32 knots might be reached.

The Institute of Chemistry.—The annual report of the Council of the Institute of Chemistry, which was presented at the 62nd annual general meeting of the Institute, held recently in London, showed that there are now 7,550 members on the roll, or upwards of five times as many as were registered in 1914. The officers for the ensuing session were elected at the meeting, the new President being Dr. J. J. Fox, C.B., the Government Chemist.

THE LATE MR. W. C. MACARTNEY.

The sudden death, on March 9, of Mr. Walter C. Macartney, managing director of Messrs. Markham and Company, Limited, Broad Oak Works, Chesterfield, has removed from British engineering circles a specialist whose extensive experience will be particularly missed at the present time, and whose personal qualities were no less highly regarded. Mr. Macartney was 63 years of age when he died at his home, Ashgate House, Chesterfield, after a relapse from a severe attack of influenza.

Walter Crealock Macartney was the son of Colonel Arthur Sutherland Macartney, Royal Artillery, and was born on April 7, 1876. He was educated at the Dragon School, Oxford, and at the Oxford Military College, where he was a contemporary of the late Sir Eric Geddes. On leaving school in 1893, he was entered as a pupil at the Elswick works of Sir. W. G. Armstrong, Whitworth and Company, Limited, at that time under the chairmanship of Sir Andrew Noble, who had gathered around him a notable staff of engineers, many of whom attained considerable distinction. In the Gunnery and Gun-Mounting Department, then under Captain Lloyd, took place practically the whole technical evolution of naval-gun and gun-mounting design, the majority of the 70 ships ordered under the Naval Defence Act of 1888 being armed from Elswick. Mr. Macartney remained on the staff after the completion of his apprenticeship, and was sent out to various shipyards to oversee the installation of the heavy gun-mounting machinery. Among other ships fitted out under his supervision were the British battleships Albion, at the Thames Iron Works, and the Mars and Glory, built by Laird Brothers (now Cammell Laird and Company, Limited), of Birkenhead. He was a keen Volunteer officer, and was one of the subalterns who accompanied the Elswick Battery to South Africa during the Boer War—one of the earliest instances of the use of a British Volunteer force overseas. He served through the whole of the war, and was promoted Captain; and, on his return, rejoined Messrs. Armstrong's staff.

In November, 1907, Captain Macartney was appointed as assistant to Mr. (now Sir) William Ellis, at the Atlas Works of Messrs. John Brown and Company, Limited, Sheffield. The two steel-making firms of John Brown and Company and Charles Cammell and Company, shortly before this date, had jointly founded the Coventry Ordnance Works, and in 1909 Macartney's experience in the manufacture of guns and their mountings led to his selection as the first works manager of this establishment, of which, before long, he was made general manager. To his organising abilities was greatly due the immense output of guns and mountings produced during the war of 1914-1918 in this works, of which he remained in charge until the cessation of hostilities caused it to be closed.

In 1918, on leaving the Coventry Ordnance Works, Mr. Macartney joined the firm of Walter Somers and Company, Halesowen, as joint managing director. He was invited by the Government to undertake the supervision of Woolwich and the other national armament factories, but the necessary restrictions of an official position did not appeal to him, and he declined the proposed appointment. In 1924, he returned to Sheffield as general manager of Messrs. Sheffield Steel Products, Limited, during the re-organisation of that firm, but three years later transferred to Chesterfield on appointment as managing director of Messrs. Markham and Company, Limited, where he remained until his death. During this association with them, the firm were closely concerned with many important tunnelling works in this country and abroad, their contracts in this field including the construction of the shields used for the Mersey Tunnel and for the numerous extensions of the London Underground system of railways. He was responsible also for the construction of various sets of large winding machinery for the Rand gold mines, and developed the manufacture at Chesterfield of water turbines for hydro-electric plants. A unique undertaking carried out under his direction was the erection at the National Physical Laboratory, Teddington, of the variable-density wind tunnel constructed by Messrs. John Brown and Company, Limited, in 1930.

Mr. Macartney was intimately concerned with the formation of the Foremen's Mutual Benefit Society, and served for many years on its Executive Council, of which he was for some time vice-chairman. He took a keen interest also in the Staff Benefit Society, acting as chairman of this organisation from 1927 until its absorption, in 1939, into the Foremen's Society. He was a trustee of the Dyer Memorial Fund, a member of the Management Committee of the Sheffield and District Engineering Employers' Association, and a former president of the Chesterfield Chamber of Commerce. He was elected an associate of the Institution of Naval Architects in 1910, and was a member of the Junior Institution of Engineers, being president of the Sheffield section of the latter institution in 1931-32.

THE LATE MR. F. W. BRIDGES.

As we go to press, we have learned with much regret of the death of Mr. F. W. Bridges, well known for many years as the organiser of the series of Shipping and Engineering Exhibitions, held biennially at Olympia. Mr. Bridges, who was 80 years of age, died on March 13, at his home at South Woodford, Essex.

THE NEWCOMEN SOCIETY.

At a meeting of the Newcomen Society, held at the Institution of Civil Engineers on March 13, two papers were read. The first was on "Electrical Invention and Re-Invention," by Mr. W. T. O'Dea, who stated that he had had occasion to examine the circumstances surrounding many notable inventions, and had attempted to classify them according to the circumstances which stimulated the inventive processes, the circumstances created by the processes, or the later circumstances which fructified previous invention. One of the lessons taught by the history of electrical engineering was the value of pertinacity. At all stages in development there were instances of phenomena explored not quite far enough, or others discovered and not fully appreciated. Although Faraday discovered, in 1821, that a conductor carrying a current could be made to rotate round a magnetic pole, and, in 1823, Davy found that a pool of mercury carrying a radial current would rotate in a magnetic field, neither of them thought at the time of forcibly rotating the conductor in the magnetic field to see if a current would be produced. It was left to Faraday and Pixii, in 1831, to make the first machine that would do this. Much interest lay in the story of the dynamo. The first proposal for a self-exciting machine appeared to have been made by Sören Hjorth, of Copenhagen, in a patent of 1855. In 1861, another self-exciting machine was proposed by Jedlik, of Budapest.* These proposals, however, led to nothing. In 1863-5, Henry Wilde, of Manchester, built machines so nearly self-exciting that it seemed amazing that he should not have continued farther. In a paper to the Royal Society in 1866, Wilde wrote that "an indefinitely small amount of magnetism or dynamic electricity is capable of inducing an indefinitely large amount of magnetism; and again, an indefinitely small amount of dynamic electricity, or of magnetism, is capable of evolving an indefinitely large amount of dynamic electricity," given, of course, the expenditure of mechanical power. In 1866, S. A. Varley patented a self-excited machine, but lost interest in the matter and did not complete his patent specification. It was left to Wheatstone and Siemens to describe their self-exciting machines to the Royal Society in 1867, thus the practical establishment of self-excitation followed the invention of the electromagnet only after an interval of many years, during which the principle had been discovered and rediscovered three or four times. Some inventions lay dormant, pending the discovery of some necessary, but ancillary device, or pending the growth of conditions suitable for their development. Examples of the former are to be found in the annals of radio and television developments, while in the latter group can be placed the secondary cell. Storage of electricity was noted by Gautherot in 1801, but there was no demand for accumulators until the introduction of electric lighting. A somewhat similar case was that of the transformer core. Faraday's original induction ring had a closed core; induction coils, however, had straight cores, and in 1856 Varley produced a closed-core design. In 1882, Gaulard and Gibbs made commercial transformers with both closed and open cores, but in 1885, Zipernowski, Déri, and Blâthy, in Budapest, were making ring-cored transformers for use on their distribution service. Some inventions were dictated by the march of events, Mr. O'Dea said; it was the introduction of the Jablochkoff electric candle, in 1877, that led to the demand for alternating current, which, again, led, a few years later, to the invention of the three-phase induction motor.

The second paper, by Mr. J. R. Nichols, was entitled "Amédée Bollée—Pioneer of Mechanical Road Locomotion." Bollée, who was born on January 10, 1844, and died on January 20, 1917, came of a family of bell-founders. His father, Ernest Sylvain Bollée, established a foundry at Le Mans in 1842, and there cast bells, and made hydraulic rams and pumping windmills. Amédée was attracted by the possibilities of mechanical road locomotion and in 1872 began the construction of a steam carriage. In this, and in another built a few years later, he introduced a method of steering embodying the principle in general use to-day. His first coach had two V-twin steam engines, each driving a back wheel through a change-speed gear and a chain. The boiler had Field tubes. Many trips were made with the coach and, on August 26,

* See page 274, *ante*.

1875, Bollée was given a permit, the first issued, to drive a mechanical passenger vehicle on the roads of France. The appearance of the coach on the streets of Paris aroused great interest and, on November 2, 1875, a report on it was read at the Paris Academy of Sciences. In conjunction with M. Dalifol, Bollée built, in 1876, a steam tramcar. Two years later, he built a steam barouche which was the only steam vehicle at the Paris Exhibition of 1878. A similar carriage was made for M. Gustave Koechlin, a manufacturer of Alsace, who afterwards ordered a goods vehicle, really a road locomotive and power-driven tender, which, in official trials, drew three loaded army wagons. Bollée vehicles were also built in Austria and Germany and considerable progress was made. The last machine made by him was a large road-roller of 22 tons, built in 1890. In 1896, he transferred the car-making side of his business to his sons and returned to the bell foundry, devoting much time to acoustics and the development of the electrical carillon.

THE SHIPBUILDING AND SHIP-REPAIRING INDUSTRIES AFTER THE WAR.*

By SIR ARCHIBALD HURD.

WHEN the mobilisation of the Navy, Army and Air Force was completed at the opening of the war in September last, the shipbuilding and ship-repairing industries passed under the control of the Government. These simultaneous events were unprecedented in the history of this or any other country. Organised by individual enterprise and financed by private capital, all the firms were uncovenanted to the State and had been free to conduct their business according to their own ideas, competing for British and foreign orders, and thus cementing profitable connections at home and abroad and creating prestige, which is an asset of greater value than is sometimes realised. Some firms had been doing work for the Admiralty for many years, but the contracts had always been concluded on a free commercial basis. Though, in the years preceding the war of 1914-18, warship work accounted for 25 per cent. of the employment in the industry, the great majority of shipbuilding, as well as ship-repairing, firms had always been engaged in commercial work under conditions of complete freedom. In September they were suddenly required to submit to complete control. Government control raises many problems which it is not too soon to consider, in order that the war crisis may not be succeeded by a post-war crisis of such a character as might threaten the economic structure, as well as efficiency, of all the industries directly and indirectly associated with the creation and use of the instruments of sea power, naval and commercial.

Shipbuilding is dependent on shipping, sharing its good fortune as well as its bad fortune. In peace, world competition among shipowners periodically resulted in a surplus of tonnage, with the result that British owners suffered losses over a long series of years. In such periods shipbuilders could expect only meagre

TABLE I.—*Gross Tonnage Launched (Annual Averages).*†

Period.	British.	Dominions Overseas.	Other Countries.	World Total.	Percentage of British Output.
1892–4	998,000	10,000	238,000	1,236,000	81·6
1895–9	1,170,000	14,000	457,000	1,627,000	72·8
1900–4	1,358,000	27,000	953,000	2,311,000	59·9
1905–9	1,396,000	25,000	934,000	2,330,000	61·0
1910–14	1,660,000	35,000	1,079,000	2,739,000	61·9

† *Report of the Departmental Committee on Shipping and Shipbuilding* (1918).

orders for new tonnage. But when, owing to the need for transports, store ships, and other auxiliaries for military operations, the shipping industry made good profits, the shipbuilding industry, in due course, became busy once more.

During Queen Victoria's reign, the two China Wars, the Crimean War, the Indian Mutiny, the Abyssinian Campaign, the Ashanti War, the Zulu War, the first Boer War, the Egyptian Campaign, and the war in South Africa of 1899-1901, led to the employment of a considerable volume of British shipping, which was also favourably affected by the wars in which other nations were engaged. As the supply of tonnage which was free for commercial purposes became restricted, the earnings of shipowners increased. They and those who had invested money in the industry shared some of the profit, and the remainder, passing into reserves, became available for the building of new ships. This, in summary, was the general course of events, and in the result British shipping increased and the shipbuilding industry expanded as the figures in Table I reveal, though, owing to other causes, the ratio of British to foreign launches declined.

In the years 1900-14, foreign shipbuilders were already profiting by State subsidies and such advantages as flow from the reservation of coastal trade. Nevertheless, in the years immediately before the war of 1914-18, British yards were still responsible for 61·9 per cent. of all the ships launched in the world.

TABLE II.—*Values of Ships Exported.*

Year.	Merchant Ships.	Men of War.
	£	£
1926	4,610,679	19,300
1927	4,485,267	45,388
1928	10,755,424	5,143,130
1929	11,690,916	3,820,250
1930	19,435,016	707,400
1931	9,857,745	600,000
1932	3,388,575	525,000
1933	1,891,919	679,928
1934	1,164,909	597,586
1935	2,203,558	874,226
1936	3,479,243	119,039
1937	2,932,705	1,140,588
1938	6,468,657	2,490,937

A large proportion were for registration under foreign flags. The importance of this work in its bearing on prices and employment has never been fully realised, either by politicians or by trade-union leaders. In combination, foreign orders for commercial tonnage, supplemented by orders from foreign Governments for men-of-war, provided a great deal of work for naval architects, draughtsmen, and skilled workers, not only in the shipbuilding districts, but in the great inland industrial centres, since orders for a new ship will provide employment in as many as sixty inland towns. The value of ships exported is shown in Table II.

When the war opened in 1914, there was no suggestion that shipping or shipbuilding and ship-repairing should be controlled. The shipyards were left free, many accepting large and urgent contracts from the Admiralty, while others continued to do such commercial work as was available, much as under peace conditions. The Government took little or no interest in the industry so long as naval requirements were satisfied. Shipowners, it is admitted, made large profits in the early period of the struggle, but shipbuilders gained little advantage from this good fortune of their customers. Before any considerable part of the profits could be invested in new tonnage, shipping came under complete control and profits were restricted. Proof is supplied by the figures of output in the year before the opening of the war and the immediately succeeding years.

"Before the war Great Britain's supremacy was even greater in building than in the size of her mercantile marine. In 1913 British yards launched about 2,000,000 tons gross and the rest of the yards of the world about a million. In 1914 her total was still over 1,500,000. After that, however, the claims on men and material for the Army and munitions had the most serious effects. In 1915 the total fell to 660,000 tons and in 1916 to 630,000 tons.

"By this time the losses were becoming serious and building seemed likely soon to cease altogether. In a general system of official control what is left to private enterprise fares badly. The prospect of requisition at Blue Book rates made the shipowner loath to order. The control of labour and of materials by Government departments, who wanted both for other purposes, made it difficult for the builder to execute even such orders as he received."*

Owing to the heavy losses during the intensive submarine campaign, the Government became alarmed, and came to the conclusion that it could meet the situation best by taking the shipbuilding and ship-repairing industries under its wing in order that only essential work should be done. Shipbuilding and ship-repairing, naval and commercial, were placed under the Admiralty, Sir Eric Geddes being appointed Controller in May, 1917. Whether this decision was for good or for ill must remain a matter for argument. At any rate, shipbuilders responded whole-heartedly in the national emergency:—

"In 1917 the innumerable types of vessels previously built in British yards were limited. About 12 types were selected, and future vessels, known as 'Standard Ships,' were built to these types. By the beginning of 1918 the number of standard ships was 42 per cent. of the total building and by the end of the year it had reached 76 per cent."†

In the conditions of panic which arose when the seriousness of the tonnage position was realised, extraordinary measures were adopted in the hope of increasing the rapid production of mercantile shipping. A new department was organised at the Admiralty, in charge of Major-General C. S. Collard, R.E., who had had no experience of shipbuilding. The first emergency measure was the extension of shipbuilding facilities in this country, with little consideration of the fact that the progress of shipbuilding depends mainly on supplies of material and of trained labour, which were already completely mortgaged. In neither respect can supply be suddenly and dramatically speeded up. Nevertheless, so great was the pressure in favour of something dramatic being done that many firms were required to increase the number of their berths and generally to expand their facilities for ship construction. It may be doubted whether this costly experiment, for the expenditure ran to several millions, produced a single ship more than would otherwise have been produced.

It was also decided, as though a miracle was about to be staged, to build what were described as "fabricated ships." Someone conceived the idea that German prisoners might be employed in building ships. As the prisoners could not be employed in the existing shipyards, for obvious reasons, it was determined to make new shipyards.

"General Collard, who had already established a yard at Richborough for the construction of small craft, proposed that national shipyards should now be established for the utilisation of German labour in the building of fabricated ships from parts made in bridge-building and constructional-engineering works, which would easily be assembled by unskilled labour.

"The site chosen was the Bristol Channel, where large constructional steel works were available, and it was proposed to build yards at Chepstow, Beechley and Portbury, with a total of 41 slips, including seven taken over from Messrs. Finch and Co., who had established a yard at Chepstow in 1916."*

Another idea was that ships should be built of concrete, and more money was provided for that project. Enthusiasts declared that construction on these lines would require less steel, while the labour employed need not be highly skilled. Moreover, the first cost, it was urged, was low and the maintenance charges moderate. When the war came to an end every order for a concrete vessel that could be cancelled was cancelled, and work on the others continued. At the end of July, 1919, 19 vessels had been delivered and 15 launched. The idea of employing unskilled labour only had to be partially, at least, abandoned, while the estimates of cost were not realised. Each concrete barge cost, on the average, 27,500*l.*, while a steel barge of similar capacity could be constructed for only 17,000*l.* or 18,000*l.* The loss on the scheme for building concrete ships was put at nearly 2¾ million pounds. The experiment was a failure from every point of view—a waste of public money. The output in 1918 of all the yards, new and old, was 1,534,000 tons, whereas the public had been led to expect one of 3,000,000 tons. To what extent even that output was due to the decision, in May, 1918, to appoint a practical shipbuilder, Lord Pirrie, as Controller-General of Merchant Shipbuilding, must remain a matter for speculation.

There is a widespread impression that the tonnage position was radically changed by the remarkable efforts made on the other side of the Atlantic, after the United States entered the war; but, in fact, few of the ships of the American war programme were completed before the Armistice was signed. The launchings—not completions—of seagoing tonnage of the United States, which had been 821,115 tons gross in 1917, rose to 2,602,153 tons in 1918, the last few months of that year witnessing the heaviest production; but it was not until 1919 and 1920 that the launchings reached 3,348,725 tons gross and 2,348,725 tons gross, respectively, falling to 1,004,093 tons in 1921. Little of the tonnage produced under the American war programme had any influence on the war.

The record of history is that the submarine was mastered by the Royal Navy, and that the effects of enemy action were neutralised by the output of shipyards of the United Kingdom, following their well-tried principles of construction, subject only to such modifications as were necessary when standard designs were adopted. The tonnage shortage of the Allies was made good by the ordinary resources of the shipbuilding industry of this country. That is an historical fact that should not be overlooked at a time when we are once more engaged in war against the same enemy employing the same unlawful methods of destruction, and the nation's thoughts, and especially the thoughts of politicians and theoretical economists, are again turned towards the shipyards after an interval of upwards of twenty years.

(To be continued).

* Paper contributed to the *Transactions* of the Institution of Naval Architects for discussion in writing. Abridged. Comments should be in the hands of the Secretary at 10, Upper Belgrave-street, London, S.W.1, not later than April 30, 1940.

* *Allied Shipping Control*, by J. A. Salter, C.B.
† *Loc. cit.*

* *Seaborne Commerce* (Official History).

LABOUR NOTES.

Referring to the conditions of appointment of Engineer Officers of the Merchant Navy Reserve, the report of the Council submitted to the annual meeting of the Institute of Marine Engineers in London, on Friday last week, stated that urgent representations had been made to the Ministry of Shipping regarding the efforts which were being made to induce certificated sea-going engineers, registered under the scheme, to accept sea service in vessels owned or operated by companies which, by reason of the poorly found condition of these ships and the low rates of pay offered, had always had difficulty in engaging or retaining qualified engineers. A deputation from the Council had been interviewed at the Ministry when the whole question was ventilated, and assurances had since been received to the effect that the suggestions put forward by the deputation were being implemented.

The deputation, the report said, had also called attention to the serious situation which was arising due to the conscription, for Army service, at the age of 20 years, of marine-engineer apprentices when they had almost completed four years' training. The supply of junior engineers, it was pointed out, was thereby diverted from the vital service of the mercantile marine. The adoption of the proposals which the Council had submitted at the Ministry's invitation would, it was anticipated, remedy the situation.

Writing in the March issue of the *Report* of the Boilermakers' and Iron and Steel Shipbuilders' Society Mr. Mark Hodgson, the general secretary of the union, states that the Minister of Labour has indicated his labour requirements for shipbuilding and engineering, and they were convinced that, with better organisation and more toleration from employers with men who had been unemployed for long periods, these requirements could be met. The society still has, Mr. Hodgson points out, 1,500 riveters on its books for whom, he says, there appears to be little demand; some of them are anxious to learn to use machines. With the men's experience of shipyard work and life, that should not, he thinks, be a difficult problem to solve. They had an agreement with the employers to meet conditions like that, and it had not been annulled. There are also a number of caulkers idle, he says, who would have to be fitted in. Their knowledge of shipyards and their skill ought to be utilised. The executive council of the Boilermakers' Society, Mr. Hodgson adds, have no dilution agreement with the employers. At the end of February, there were over 3,020 idle members on the books, as compared with 3,477 at the end of January.

It was agreed at a meeting at the Admiralty last week of the Shipbuilding Trade Joint Council, for Government Departments to increase the bonus for adult male workpeople in Royal Dockyards and other Admiralty establishments at home by 5*s.* a week, as from February 19. The effect of this increase will be to raise the standard rate of bonus for these workpeople from 22*s.* to 27*s.* a week. Increases have also been granted as from the same date in the rate of bonus for apprentices and boys in the above establishments.

It was announced last week by the Staff Side of the National Whitley Council for Civil Servants that Sir John Simon had again refused the request for the appointment of a joint committee to negotiate a cost-of-living increase of pay. In his letter, the Chancellor said that "after giving full weight to the arguments which are again put forward in your letter and to the recorded facts as to the numbers and classes of workers who have received increases of pay since the outbreak of war—only a small proportion of whom can be regarded as closely comparable with Civil servants—I am afraid I cannot agree with the conclusions you have reached. While the position generally has undergone some modification since I met members of the staff side, there has not, I think, been any such substantial change as would justify me in modifying the views which I have expressed." An official of the staff side, commenting on the letter, contended that the large number of Civil servants receiving 3*l.* a week or less and the 70 per cent.—or nearly 300,000—getting no more than 4*l.*, were closely comparable with the 7,000,000 or 8,000,000 outside who had been given pay increases since the beginning of the war.

The Committee on Workers' Holidays has issued an appeal to local authorities, to employers, and to representatives of workpeople in the industrial districts to arrange meetings at an early date to discuss local arrangements for bringing about a spread-over of the holiday period. The committee, which was formed by the Industrial Welfare Society at the suggestion of the Minister of Labour for the purpose of studying questions arising out of the findings of the Government Committee on Holidays with pay, agrees with Lord Amulree's committee that an annual holiday contributes to the happiness, health, and efficiency of workpeople. If the workers are to meet the demands of war-time production without excessive strain, a holiday, except in sudden or grave emergency, is therefore more vital than in peace time. It agrees further that as a result of the use of normal holiday accommodation for various war time purposes, and the limitation on transport by road and rail, it is essential that holidays should be spread over the months of May to October.

Railway officials whose work is connected with the running of trains engaged upon the transport of holiday-makers have always been enthusiastic supporters of staggered holidays. They consider that the spread of the holiday season over a longer period is particularly important this year, when it may not be possible to arrange for the full summer services to which the travelling public have become accustomed.

Replying to a question in the House of Commons, Mr. Ernest Brown, the Minister of Labour and National Service, said that since the Holidays with Pay Act came into operation in July, 1938, orders requiring employers to provide holidays with pay had been issued in respect of 49 trade boards, covering rather more than 1,000,000 persons. In a further six cases notices of proposal to make such an order had been issued. In regard to agricultural wages committees, he was informed that orders had been issued in respect of all areas (with the exception of Monmouthshire) into which Great Britain was divided for the purpose of the Agricultural Wages Acts. These orders covered about 600,000 workpeople. In addition, an order relating to the road motor haulage industry had been issued by the Road Haulage Central Wages Board, making holidays with pay for employees of A and B licence holders in Great Britain statutorily enforceable as from January 29, 1940. It was estimated that the number of persons covered by collective agreements providing for holiday with pay was now about 4,500,000. This compared with an estimate of 3,000,000 made by the Amulree Committee when presenting their report in March, 1938.

The Unemployment Insurance Statutory Committee's annual report on the state of the Fund says that if unemployment had taken the course for which the Committee had made provision in accumulating a reserve, the expenditure of the fund during 1939 would have exceeded the income by 8,250,000*l.* In fact, the income had exceeded the expenditure by about 16,600,000*l.*, so that the fund was nearly 25,000,000*l.* better off than if the Committee's expectations had been realised. There was room for argument as to whether the whole of the unexpected improvement was due to defence expenditure, but some, if not all of it, must be attributed to this cause. In part, therefore, it was of the nature of war profits.

The report states that, looking to the future, it appears certain that the end of the present war will be followed, as was the end of the last war, by severe unemployment, though it may not be immediate and the rise may not be as great as in 1921 and 1922. But whatever is done, the transition from war to peace production cannot be accomplished without severe dislocation. In the Committee's opinion, a period of eight years from now—the trade cycle period adopted by the Committee—will cover both the war and a substantial depression thereafter. "The war, in effect, makes impossible (the report says) any reasonable forecast of the future course of unemployment beyond the general forecast that any great reduction of unemployment during war is certain to be followed by a great rise of unemployment after it."

The *Times* correspondent in Rome states that the Central Corporative Committee—the supreme organ of Italy's economic life—has decided that the prices of certain foodstuffs and articles of prime necessity shall be blocked at their present level until July 31 next, and that a general increase of from 10 per cent. to 15 per cent. in wages and salaries shall come into force from March 25. This increase does not apply to State employees, whose position, however, will be settled by the Council of Ministers, which meets on April 2. The resolution of the Central Corporative Committee embodying these decisions states that the rise in prices in Italy is connected with the world situation caused by the war, and especially "by the economic character which has been given to the present conflict." The Committee calls upo nmanufacturers and wholesale retail traders to give proof of their discipline and civic sense and asks all Italians to "realise that the position in which Italy finds herself is delicate and such as to demand the necessary limitations."

The correspondent adds that wages in Italy had been lagging behind prices since the last general wage increase—from 5 per cent. to 10 per cent.—took place a year ago. Its benefits, however, had gradually been nullified by the steady rise in the cost of living which all the efforts of the Government have been powerless to curb. The foregoing decisions will, it is believed, have a tranquilising effect on the mass of Italian workers, most of whom were beginning to feel the pinch and were regarding the immediate future with unconcealed anxiety.

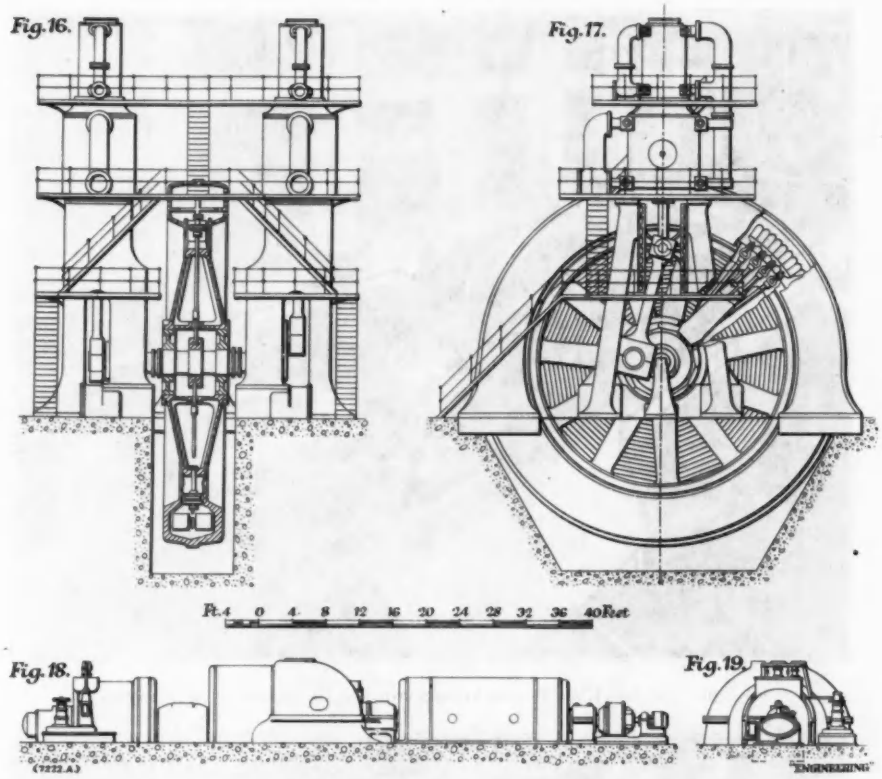
The Governing Body of the International Labour Organisation has approved the programme of work for the Office in 1940. The subjects selected for study are as follows:—Men disabled in war: their right to compensation and their vocational and social rehabilitation; Problems of organisation of the labour market arising out of the war; Vocational retraining as a continuous means of adapting the supply of labour to the demand; The influence of the war and mobilisation on national regulations concerning hours of work and rest periods; The influence of the war and mobilisation on the conditions of work of women; The adjustment of wage rates to changing prices; The adaptation of social insurance to mobilisation and war; The organisation of medical labour inspection, and the factory doctor: his training and functions; Safety in the loading and unloading of ships; Agricultural problems of Central and South America; Industrial Relations in colonial territories; The conditions of workers and their families (low-cost housing).

During the discussion on the Directors' Report at the recent meeting of the Governing Body of the International Labour Organisation, Mr. Justin Godart, French Government representative, made a statement on behalf of the French Government with regard to the application of international labour Conventions in war time. A certain number of these Conventions provided that their application might be suspended in the event of war or in case of serious emergency. It had become necessary, Mr. Godart said, for countries which were upholding the ideals of justice, morality and freedom to take all possible steps for their legitimate defence and for the safety of civilisation; they could not, therefore, allow their efforts to be restricted by the rules which had been accepted in peace-time, although they would do everything in their power to respect as far as possible the regulations adopted for the protection of the workers. At no time in history had those States been faced by a more obvious case of *force majeure*, which would entitle them, for their own security and in order to ensure the victory of the democracies, to make certain exceptions in the provisions of the Conventions which they had ratified. They were, therefore, entitled and, indeed, bound to do so without running the risk of being accused of acting in a manner contrary to the spirit or the letter of the constitution of the International Labour Organisation.

Mr. Jouhaux, Workers' representative (France), said that countries acting in legitimate self-defence could not be prevented from making certain exceptions to international labour Conventions, more particularly since they were fighting for the very ideals of the Organisation which had adopted those Conventions. But such exceptions should only be made after discussion with the interested parties, namely, the employers' and workers' organisations which had taken part in adopting those Conventions. In that way the principle of collaboration, which was the basis of international labour legislation, would be safeguarded.

The writer of an editorial note in the *Journal* of the International Association of Machinists states that all America's labour organisations are, and have always been, non-partisan in politics. That they will continue to be so is, moreover, his firm belief. "While it is true," he says, "and, of course, proper, that those entrusted with the administration of the affairs of the various Labour Organisations on this Continent do, after a careful survey and analysis of the records of those seeking election or re-election to public office, sometimes advise their membership whom to support, it is also true that the American trade unionist has and will exercise the right to vote for candidates of his own choice without interference on the part of anyone. And this is as it should be; otherwise we should have a political oligarchy with all its attendant evils. No man or group of men has ever controlled the so-called labour vote, and certainly anyone who believes that it can be delivered to any party or to any candidate, has little knowledge of the history of the American labour movement."

MECHANICAL ENGINEERING IN POWER STATIONS.



FORTY YEARS' DEVELOPMENT IN MECHANICAL ENGINEERING PLANT FOR POWER STATIONS.*

By SIR LEONARD PEARCE, C.B.E., D.Sc.

(*Continued from page* 264.)

I NOW propose to deal with some of the engineering developments for which, as Engineer-in-Chief of the London Power Company, I have been responsible. The company was constituted under the Electricity (No. 2) Act of 1925, to act as the generating authority for ten London electricity-supply companies. It took over the existing generating stations and transmission lines and had powers to construct other stations and lines. The area of supply extends from Greenwich on the east to Willesden on the west, and may be said to include the heart of London. It embraces the several areas of supply of its ten (now nine) constituent companies. In addition, the company had wide powers to afford supplies in bulk and to railway authorities.

In 1926, eight power stations were operated by the company, having a total installed capacity of 337,350 kW, the largest being the Deptford East station, with a capacity of 106,180 kW. In general, the steam conditions at the various stations were 200 lb. to 325 lb. per square inch pressure, and 500 deg. to 700 deg. F. total temperature. The policy of the company has been to close the smaller and less efficient stations, to improve and extend the more efficient stations, to erect new capital stations with modern units of large capacity, and to provide a 66,000-volt primary transmission system interconnecting the various power stations, and a 22,000-volt secondary distributing system.

In conformity with this policy it was decided, therefore, in 1926, to formulate plans for the erection of a new riverside station at Deptford West. This was adjacent to the historic Deptford East station (originally built in 1887-8), with which the name of that great pioneer, Dr. S. Z. de Ferranti, will always be associated, and where the first steps in the world may be said to have been taken in the generation and transmission of high-pressure alternating currents. The steam conditions specified for the Deptford West station were 350 lb. per square inch, 750 deg. F., at the turbines, with a condenser vacuum of 29·0 in., the turbines throughout being of the two-cylinder impulse type, running at 1,500 r.p.m. Feed heating to a temperature of 250 deg. F. was arranged for. The first two generating sets, supplied by the British Thomson-Houston Company, were rated at 25,000 kW each (subsequently raised to 30,000 kW), and are shown in the foreground of the general view of the turbine room in Fig. 14, on page 308.

Eight boilers having a maximum rating of 95,000 lb. per hour each, at 375 lb. per square inch and 780 deg. F., were installed, four of these being of the Babcock and Wilcox header type and four of the Stirling bent-tube type. The boilers were complete with interdeck superheaters, economisers, and plate-type air preheaters, the air temperature at entry to the grates being about 200 deg. to 250 deg. F. Six of the units were provided with chain-grate stokers and two with retort stokers. A view of the boiler house is shown in Fig. 13, on page 308. Between 1929 and 1937, the station was extended by the addition of three Metropolitan-Vickers 35,000-kW and one 50,000-kW turbo-alternators, the steam supply being furnished by ten boilers varying in output from 130,000 lb. to 300,000 lb. of steam per hour.

The larger boilers which have been installed in recent years, built by Messrs. John Thompson, are all fired by the Taylor retort-type of stoker, as is the case with the last boiler to be installed at this station, namely the 280,000/350,000-lb. per hour Thompson-La Mont forced-circulation unit. It is significant that, due to the great strides made in the design of plant in the short space of ten years, a station planned originally for 25,000-kW turbines and 95,000-lb. per hour boilers should have as its latest additions a turbine of 100 per cent. and a boiler of 270 per cent. greater capacity, arranged in the space which was originally allotted for the smaller units.

It is interesting to compare the latest 50,000-kW turbine set at Deptford West with the early 10,000-h.p. engine-driven generators projected for the original Deptford East station, to which I have already referred, and views of each machine, drawn to the same scale, is shown in Figs. 16 to 19, above. It will be noted that the electrical generators at Deptford East were arranged between pairs of 5,000-h.p. engines.

An external view of the completed station as it exists to-day is shown in Fig. 15, on page 308, and it is interesting to note that tall reinforced-concrete chimneys have taken the place of the short steel stacks with which this station was originally equipped and how, in addition, substantial towers to contain modern gas-washing equipment have been superimposed on the north elevation of the building.

I now turn to the Battersea station, the designs for which were commenced in 1927. These provided for an ultimate installed capacity of approximately 500,000 kW, built in two sections. It was felt that, as Battersea was to be a high load-factor station operating on a base load, it was desirable to equip the station with plant working on as commercially efficient a cycle as possible. The latest practice in this country at the time was the use of the straight regenerative cycle, with initial steam pressures of 350 lb. to 400 lb. per square inch and total temperatures of 750 deg. to 780 deg. F. In the United States, considerable prominence was being given to the reheat cycle with pressures of 1,200 lb. to 1,300 lb. per square inch and temperatures of 700 deg. to 725 deg. F.

After full consideration of all the factors involved it was decided to make a definite step-up in terminal conditions. The first installation was therefore designed for a steam pressure of 600 lb. per square inch at the boiler, with 570 lb. per square inch at the turbine, the corresponding temperatures being 830 deg. and 800 deg. F., respectively. The straight regenerative cycle was adopted, with a feed temperature of 340 deg. F. and a vacuum of 29·1 in. Since that time this cycle has been adopted in about 30 stations in this country, and it appears to have become stabilised as the next general step above the 350-lb. per square inch, 750-deg. F., 250-deg. F. feed cycle adopted at Deptford West.

The order for the initial installation of two turbo-alternators was placed in 1928 with the Metropolitan-Vickers Electrical Company and the British Thomson-Houston Company, respectively, each unit being of the three-cylinder impulse type with double-flow exhaust and twin condensing plant (supplied by Richardsons, Westgarth and Company), directly coupled to a 64,000-kW main alternator and a 5,000-kW house alternator on the same shaft. The machines run at 1,500 r.p.m., and generate three-phase current at 50 cycles per second, the voltage of the main alternator being 11,000 and of the house alternator 3,300. The first six boilers are of the Babcock and Wilcox straight-tube header type, with interdeck superheaters, bare-tube economisers, and tubular air preheaters. The units are fired with Taylor retort stokers.

In giving their consent to the erection of the station in 1927, the Electricity Commissioners made it conditional that the company should take the best known precautions for preventing, as far as practicable, the evolution of oxides of sulphur, and generally for preventing any nuisance arising from the generating station. The solution of this problem had not up to this date been presented to any authority. In order to comply with this obligation, the London Power Company embarked upon a long series of large-scale experiments in the design and performance of gas-washing plants, the outcome of which was eminently satisfactory and resulted in the installation of the well-known gas-washing plant.

In 1933, extensions were put in hand to complete the first half of the station, and once again the rapid improvements which were being made in the design of plant became evident. It was found possible to arrange a turbine and boilers of considerably increased capacity in the same space as that occupied by the earlier units. This extension took the form of a 105,000-kW three-cylinder turbo-alternator plant built by the Metropolitan-Vickers Electrical Company, generally of the same type as the previous units, the main alternator being rated at 100,000 kW and the house alternator at 5,000 kW. The turbine has a double-flow exhaust with twin condensing plant, and the overall length of the set is 120 ft. Although exceeded in size by several units in the United States, this set was and remains the largest unit installed in any European power station. A view of the set itself is shown in Fig. 20, and a view of the completed turbine room in Fig. 21, on page 318.

To provide steam for this new unit three further Babcock and Wilcox boiler units, having a maximum continuous rating of 375,000 lb. per hour, were installed. These boilers are of the straight-tube header type with interdeck superheaters, but the economiser is of the gilled-tube type and the air heater of the rotary regenerative type, the boilers also being fired by Taylor retort stokers. A general view of the completed boiler-control aisle is shown in Fig. 22, on page 319, the latest units appearing in the foreground. The steam pressure and temperature for the last extensions were increased to 625 lb. per square inch and 875 deg. F. at the boilers giving 600 lb. per square inch and 850 deg. F. at the turbine.

In 1936 it became necessary to consider commencing the second half of the Battersea station. Operating experience with the 600-lb. per square inch, 800-deg. F. plant in the first half, known as the "A" station, had been remarkably free from trouble, and had demonstrated that steam temperatures of 875 deg. to 900 deg. F. could safely be carried for long periods, which suggested the consideration of even higher temperatures. The desirability of attaining a high thermal efficiency was emphasised by the general rise in price of fuel during recent years. In considering large power-plant designs, particularly for a new station, it is always essential to bear in mind that some two or three years must elapse between the date when the

* The 26th Thomas Hawksley Lecture, delivered before the Institution of Mechanical Engineers on Friday, January 19, 1940. Abridged.

scheme is projected and the date when the plant is actually put into commission. In order that full advantage may be taken of the latest developments available at the latter date, it is therefore necessary at the time of planning to consider not only the established practice of the day, but also the probable developments which might occur during the next few years.

The great strides which had been and were being made by metallurgists in developing materials possessing increased creep resistance at higher temperatures had shown that, on the basis of laboratory tests, at any rate, materials were available which would be suitable for operating steam temperatures of the order of 950 deg. to 975 deg. F. The commercial use of materials for higher temperatures may be considered as passing through three phases, first, the evolution of material in the laboratory; second, the development of the necessary fabrication processes; and, third, the final design and operation of the plant of commercial size.

Taking the long view in 1936, it appeared that, by 1939-40, the materials in the 950 deg. to 975 deg. F. class would have passed into the third category, and it was therefore decided to adopt a steam temperature of 950 deg. F. at the turbine and 965 deg. F. at the boilers for the Battersea "B" extensions. The next matter which had to be considered was the operating steam pressure. It was obvious that if any such increase were to be made at all it should be a substantial one, and consideration was therefore given to the use of pressures falling within the range from 1,000 lb. to 1,500 lb. per square inch.

The main factor involved was the percentage of moisture formed in the exhaust from the turbines, and after many studies it appeared that an operating steam pressure of 1,350 lb. per square inch at the turbine (with 1,420 lb. per square inch at the boiler) was possible without exceeding the safe limits of moisture in the exhaust steam, provided that full advantage was taken of the latest available designs for interstage drainage and the protection of turbine blades. The question of adopting the straight regenerative or reheat cycle was given careful thought, and, after taking into account thermal efficiency, capital

Table II.—*Developments in the London Power Company's System.*

Year.	1926.	1938.	Percentage increase (+) or decrease (−).
Number of stations ..	8	6	−25
Total installed plant capacity, kW ..	337,530	892,900	+165
Total electrical units generated per annum	452,333,848	2,480,329,210	+470
Maximum demand, kW	196,303	672,500	+243
Average thermal efficiency on units generated, per cent.	14·8	24·76	+67·2
Average coal consumption per unit generated, lb. ..	2·15	1·139	−47
Highest annual thermal efficiency of any station on units generated, per cent.	17·5	28·98	+65½
Lowest coal consumption of any station on units generated, lb. ..	1·76	0·862	−51
Maximum terminal conditions of plant installed or on order :—			
Steam pressure, lb. per sq. in. gauge	325	1,420	+337
Steam temperature, deg. F.	700	965	+37·8
Vacuum, in. of mercury	29	29·1	—
Final feed temperature, deg. F.	180	400	—

cost, space considerations, boiler design and plant layout, the straight regenerative cycle, with a final feed temperature of 400 deg. F., was decided upon.

Having regard to the paramount necessity of maintaining continuity of supply, even if temporary troubles are experienced, due to the extra high pressure and temperature adopted, it was decided to construct the new plant in two-line units, namely, an extra high-pressure primary set of 16,000 kW, running at 3,000 r.p.m., and a high-pressure secondary set of 84,000 kW running at 1,500 r.p.m. The intermediate pressure between the two sets was fixed at 600 lb. per square inch, so that in an emergency the secondary set could be temporarily operated directly from the "A" station boilers.

The present designs for Battersea "B" envisage the completion of the station by the installation of three of these 100,000-kW combinations, the order for the first having been placed in 1937. To furnish steam for these, two boilers are to be provided for one 100,000-kW turbo-alternator group, each boiler having a maximum continuous rating of 550,000 lb. of steam per hour. It is not possible to detail all the considerations which enabled this final decision to be taken. One of the main factors, however, was that, with the 100,000-kW plant, working at ratings between the normal economic and the maximum continuous, the two boilers together would only be operating at about their most economic point, so that high boiler availability might be expected. On the other hand, in emergency, with only one boiler in service, it would still be possible to carry about 60 per cent. to 65 per cent. of the maximum continuous rating of the 100,000-kW turbine plant. Throughout the initial stages of design the objective was to obtain high availability comparable with that realised with turbine plants, and for this purpose the new boiler unit was designed with combustion chambers of such size as to give a low heat-release value.

This retrospective review of the developments which have taken place in two of the leading public electricity utilities of this country will have afforded some indication of the rapid developments of mechanical engineering, as applied to power-station practice, which are to be recorded during a comparatively short space of years. These developments have been fostered largely by the striking expansion of the electricity supply industry during the period under review.

That the policy of concentrating production—so far as is reasonably possible—in a few well selected and interconnected stations is sound, may, perhaps, be conveniently shown in Table II, herewith, which gives some idea of the rapid developments which occurred in the twelve-year period from 1926 to 1938 in the London Power Company's system.

(To be continued.)

MECHANICAL ENGINEERING IN POWER STATIONS.

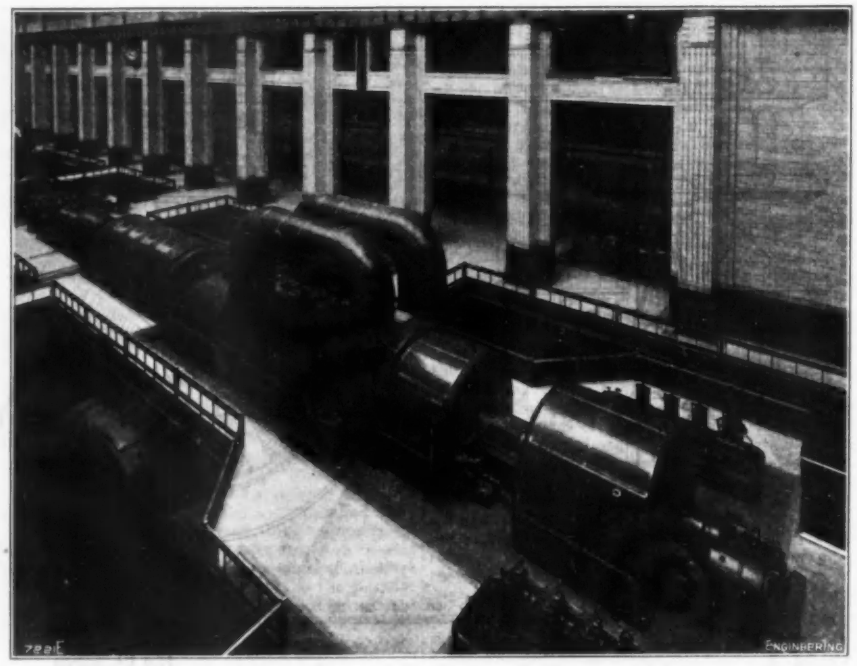


Fig. 20. 105,000-KW. Turbo-Alternator in Battersea "A" Station.

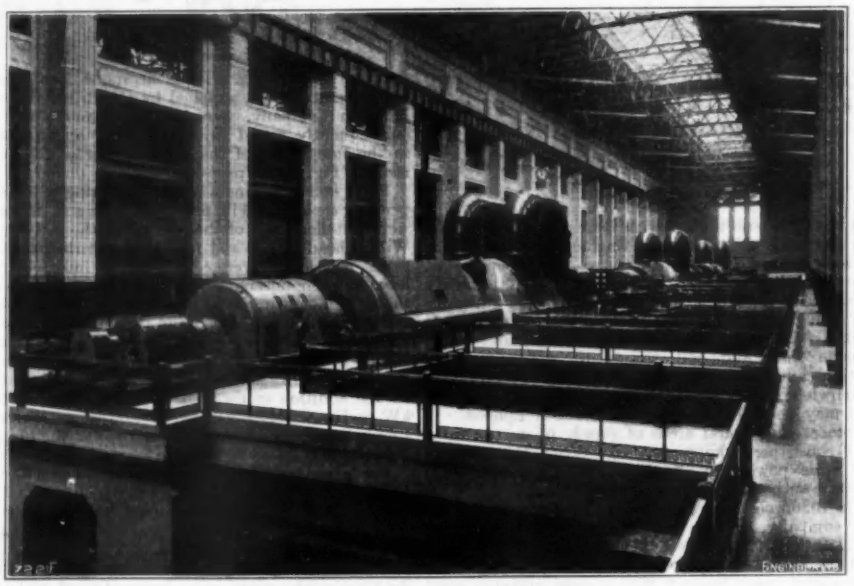


Fig. 21. Turbine Room of Battersea "A" Station.

Sand-Bag Manufacture in India.—An order for 500 million sand bags, said to be the largest since the outbreak of the war, was placed, early in the new year, with the Indian Jute Mills Association, Calcutta, by H.M. Government in the United Kingdom, through H.M. Government in India. *The Indian Textile Journal* states that this and the previous contracts are to be completed by the end of April.

MECHANICAL ENGINEERING IN POWER STATIONS.

(For Description, see Opposite Page).

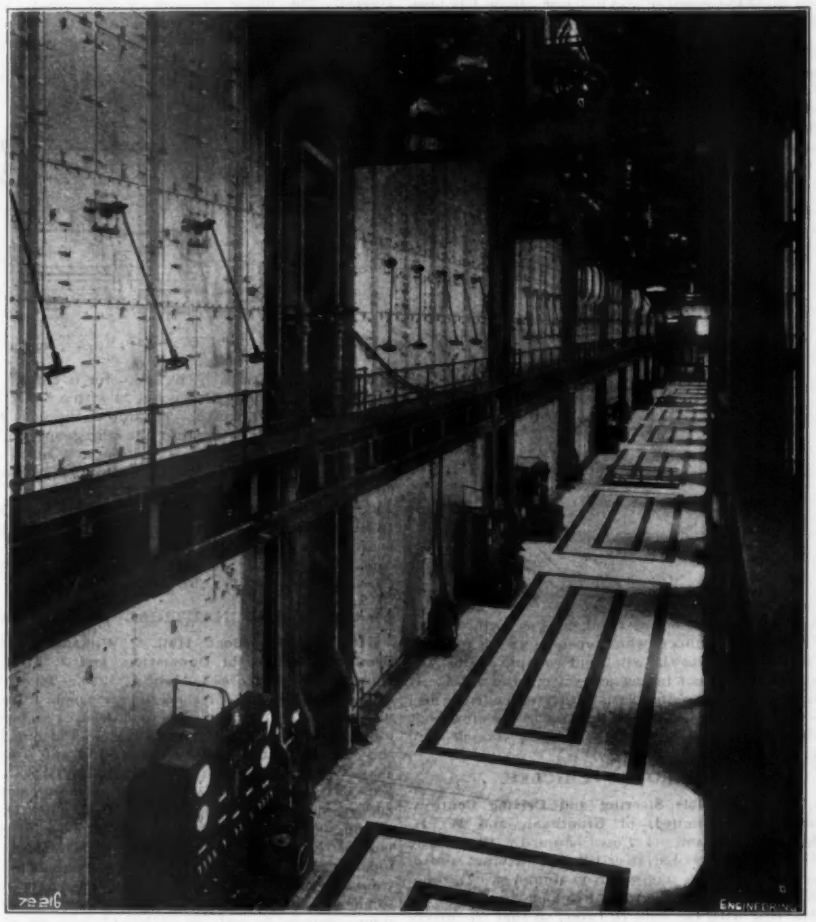


FIG. 22. BOILER-CONTROL AISLE IN BATTERSEA "A" STATION.

MEASURING THE FREQUENCY OF ALTERNATING-CURRENT POWER SUPPLIES.

WITH a view to facilitating the synchronisation of machines and systems, and to provide a better service to consumers, most electricity supply authorities in this country have now installed apparatus whereby the frequency can be maintained very close to a specified figure. This has enabled the consumer to use the mains as a low-grade frequency standard and synchronous motors can therefore be employed for many purposes, of which clocks are the best known example, where constancy of speed is essential. While the average error on the London supply network is between 5 seconds and 10 seconds, and the maximum not more than 20 seconds, for many of the drives and for frequency standard purposes it is the maximum instantaneous frequency error which is of importance. This is more difficult to assess as it is not directly limited by the control. When, therefore, the Post Office Engineering Department contemplated the use of synchronous motors for a number of drives, such as teleprinters, it was decided to take records of the frequency error on power-supply networks to determine whether they would be satisfactory.

The special error-totalising equipment devised for this purpose is described in a paper read before the Meter and Instrument Section of the Institution of Electrical Engineers on Friday, March 1, by Messrs. F. O. Morrell and G. R. Oman. For this purpose a twentieth harmonic is generated in the power supply and this harmonic is filtered and matched against a standard 1,000-cycle supply. A beat of the difference frequency is thus obtained. This beat frequency is used to drive a uniselector for a predetermined time interval and the number of beats within this interval determines the contact on which the uniselector comes to rest. An impulse is next given through the selected uniselector contact and operates the corresponding counting meter. The apparatus then resets. Ten such meters are provided to cover a maximum error of 0·5 per cent. in steps of 0·05 per cent. The operating cycle is completed in 15 seconds, and the meters record the number of periods in which the frequency has departed from the standard in each range of errors.

Tests were carried out over four principal periods in the years 1937-40, the results obtained being subjected to statistical analysis and the error curves plotted. In a typical example, 26·63 per cent. of the readings were recorded on the first meter, indicating an error of less than 6·05 per cent. and 58·83 per cent. on the first two meters, indicating an error of less than 0·1 per cent. It was found, as a result of statistical analysis, that the figures followed closely a normal error curve of distribution, it being assumed that the average frequency was exactly 50 cycles per second and that the positive and negative errors were equal. The standard deviation of the normal error curve, *i.e.*, the r.m.s. value of the error, was computed to be 0·114 per cent. For a series of continuous tests in 1938, the standard deviation was 0·106 per cent., as compared with 0·175 per cent. in 1939. During day tests in 1938 the standard deviation was 0·115 per cent., as compared with 0·1 per cent. during the night. For tests conducted over the week-end, a figure of 0·107 per cent. was obtained. The speed tolerance figure for teleprinters is $\pm$0·75 per cent., and the normal error shows that the probability of an error greater than this occurring is only 0·00184 per cent., *i.e.*, less than 0·2 minute per week, which is negligible. For 99 per cent. of that time the error would not exceed 0·45 per cent. It is, therefore, considered that a synchronous-motor drive should be quite satisfactory for these machines. In fact, it would probably be better than the direct-current governed motor.

CANADIAN OIL PRODUCTION.—The production of crude petroleum in Canada during 1939 reached a new high record of 7,743,000 barrels, as compared with 6,966,084 barrels in 1938. Twenty-six new wells were brought into operation during the year in the Turner Valley, Alberta, and an intensive exploration programme was carried on.

HEAT TRANSMISSION IN EVAPORATIVE CONDENSERS.

DURING recent years, the evaporative condenser has been gaining in popularity, not only in the refrigeration, dairy and brewing industries, but in many other applications where a copious supply of cooling water is not available. An investigation to determine the heat-transfer coefficients, and to elucidate the mechanism of heat transmission in plant of this type, was undertaken, therefore, by Dr. A. K. G. Thomsen, A.I.C., with the assistance of a grant from the Leverhulme Trustees, and has been printed in the *Transactions* of the Institution of Chemical Engineers. In a film cooler, in which the liquid to be cooled passed through horizontal tubes connected to headers, the cooling water flowing over the outside of the tubes, two effects are possible: (1) the tubes may be flooded with water, the sensible heat of which is increased without causing evaporation, or (2) a thin, yet complete, film of water may be maintained on the outside of the tubes, the water being continuously evaporated. Dr. Thomson's earlier experiments* had dealt solely with effect (1), in which he had shown that the film of water flowed over the tube in viscous motion. It was concluded that, to obtain higher values for the heat-transfer coefficient without an unduly high rate of flow of the cooling water, it would be necessary to promote disturbance of the film, either by evaporating the film itself, or by forced-air circulation. The work now reported was undertaken to test the validity of this conclusion and to determine the coefficients of heat transfer. Because of uncertainty regarding the relations between evaporation, vapour pressure and temperature, it was decided to investigate first the evaporation from a cylindrical surface.

The first experiments were on the heat transfer by forced convection between a steel tube, 1½ in. in internal diameter, and a stream of air, the tube being mounted in a wind tunnel and heated internally by six electric panels. Separate control and measurement of the current supplied to each heater enabled the average rate of heat transfer for the tube as a whole to be measured, and also the local rate for each section of the tube. The amount of heat, H, transferred from tube to air was given by the equation $H = 0{\cdot}05\,V^{\frac{1}{2}}\,\theta$ K calories per hour per metre length, V being the air speed in metres per hour and θ the difference of temperature between tube and air. The local rate of heat transfer was found to reach a maximum at the front and rear of the tube. The minima, at the sides, was found to be at an angle of about 105 deg., with respect to the direction of air flow.

Consideration was next given to the transfer of heat between the surface of a tube and a film of water evaporating into a stream of air. The rate of evaporation from a saturated surface was investigated by covering the same internally-heated tube with a thin sheath of linen, kept saturated with water. The rate of evaporation, E, was given by the equation $E = 2{\cdot}53 \times 10^{-6}\,V^{\frac{1}{2}}\,(p_w - p_a)$ grammes per second per centimetre of length, V being the air speed in m. per hour and $(p_w - p_a)$ the difference in vapour pressure, in mm. of mercury, between the surface and the air.

As in heat transfer by forced convection, it was found that the local rates of evaporation exhibited maxima at the front and minima at the sides of the tube. An evaporative condenser was constructed by replacing the internal electric heater with steam, and removing the linen sheath. The rate of evaporation was then found to be greater than with the linen in place, to an extent depending on the thickness of the film of water on the tube. The rate of heat transfer was found to be largely dependent on changes in film thickness, and could be increased to as much as 25 per cent. above that of the film type of cooler under the same conditions. This was attributed to turbulence, set up in the water film as a result of the evaporation. An equation for calculating the coefficients of heat transfer was derived from first principles, and it was found that the simple equation, $Q = h_g\,A\,\Delta\,t$, at present used for ordinary condensers, gave results which were not seriously in error, provided that the evaporation did not exceed 8 per cent. of the water entering the condenser.

The similarity between the processes of heat transfer and evaporation into an air stream induced some subsidiary experiments on the flow of air across a tube. By photographing the air in the neighbourhood of the tube, it was found that break-away from the boundary layer occurred exactly in the same positions as the points of minimum heat transfer and evaporation. This was considered to support the theory that the transfer of heat, from the surface of a solid to a fluid flowing past it, took place by molecular conductivity through a thin layer of fluid close to the surface, the transfer reaching a minimum value where the layer was thickest and the skin friction least.

* Reported in *Jl. Soc. Chem. Ind.*, vol. 56, page 380T (1937).

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the communicators are given in italics.

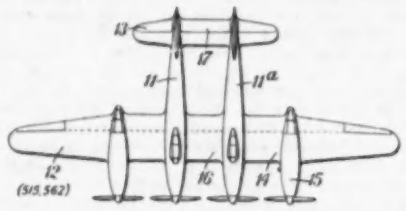
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification in each case, is given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

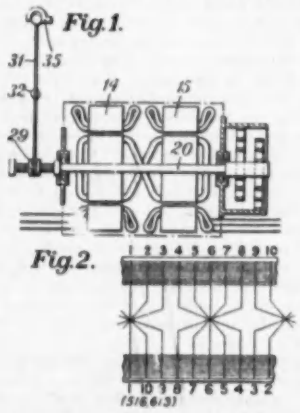
AERONAUTICS.

515,562. Convertible Aircraft. The Fairey Aviation Company, Limited, of Hayes, and M. J. O. Lobelle, of Langley. (9 *Figs.*) July 1, 1938.—The invention is an aircraft which is easily convertible from a single to a multi-engined machine, and from a single- to a double-



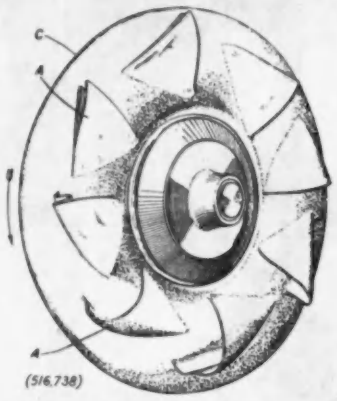
fuselage craft. An aircraft having detachable wings 12 and tail-planes 13 secured to the fuselage 11 by standard fixings is converted into a twin-fuselage aircraft by the addition of a second fuselage 11*a* and centre sections 16 and 17 for the main and tail-planes, respectively. A multi-engined craft is formed by adding integral engine nacelles 15 and wing-sections 14. (*Accepted December* 7, 1939.)

516,613. Airscrew Synchroniser. Rolls-Royce, Limited, of Derby, Newton Brothers (Derby), Limited, F. Newton, of Derby, and Rotol Airscrews, Limited, of Gloucester. (7 *Figs.*) May 11, 1938.—The invention is an airscrew-synchronising unit of the rotary type which does away with slip rings and brushes and hence reduces radio interference and the risk of fire. Two fixed stators 14, 15 have their windings connected to three-phase alternators one of which is driven by the master engine of a multi-engined aeroplane and the other by the follower engine. The windings generate two fields rotating in opposite directions at speeds proportional to the speeds of the respective engines. The shaft 20 carries two rotors, each having two poles and five slots per pole, the windings on each rotor being reversed with respect to the other (Fig. 2), and connected to common end rings. An oscillating flux common to both elements can only penetrate such a winding non-inductively at the diameter containing slots No. 1 and No. 6. The rotor shaft will therefore, tend to take up a position in which the magnetic



reluctance is a minimum, and the rotor will rotate at half the difference of the speeds of the two fields produced by the stator windings. A screw-threaded extension of the rotor shaft is engaged by a nut 29, which is engaged by the forked end of a spring 31, which is pivoted at 32. The other end of the spring engages a valve-rod 35, which controls the supply of oil to and from the hydraulic motor which adjusts the pitch of the airscrew driven by the follower engine. Should the two engines not be in synchronism, the rotor shaft rotates and the nut 29 moves along the screw-threaded portion. The blade pitch of the follower airscrew is thus altered so as to restore synchronism. There will be a time interval between the movement of the nut and the change in the blade pitch, and where there is a wide discrepancy between the speeds of the engines, the nut will travel to one or other extremity of the thread and mechanically lock the rotor-shaft 20 until the speed of the follower engine has been corrected. (*Accepted January* 5, 1940.)

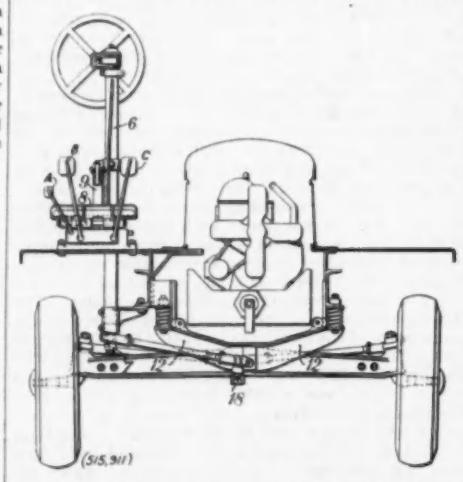
516,738. Aircraft Landing Wheels. Vickers (Aviation), Limited and Flight-Lieut. M. Hare, of Weybridge. (1 *Fig.*) July 6, 1938.—Due to the large size of the landing wheels of modern aircraft, the force required to accelerate them on landing is so great as to cause excessive tyre wear. The invention is an aircraft landing-wheel tyre which spins under the action of the airflow in the direction in which it will rotate after contact with the ground. The



side wall of the tyre C has wind cups A formed from strips of fabric or rubber, which open to give a rotating effort when facing into the wind, but collapse against the wall of the tyre when facing away from the wind. If the undercarriage remains permanently extended, wheel brakes prevent the wheels from rotating in the air except immediately before a landing. (*Accepted January* 10, 1940.)

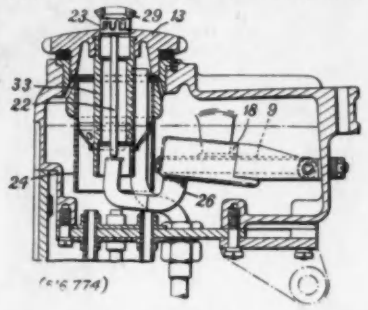
MOTOR ROAD VEHICLES.

515,911. Reversible Steering and Driving Controls. Aveling-Barford, Limited, of Grantham, and W. H. Bramble, of Grantham. (4 *Figs.*) June 15, 1938.—The invention is a reversible steering and driving control for use primarily on motor-driven dumpers. In practice it is usual for this class of vehicle to be steered from the rear with the load in front, so that the driver can see where the load is to be dumped, but when on the road the vehicle must be front steering. Attached to the longitudinals are platforms, the offside one carrying the



reversible control mechanism. Dual handwheels are fast on opposite ends of a worm spindle, the worm meshing with a segment on a vertical shaft mounted in a column 6 extending beneath the platform. To the lower end of the shaft is fixed an arm 7 coupled to the track rods. A platform 8 and a bracket 9 revolve on the column, the platform carrying the clutch, brake, and accelerator pedals. The bracket supports the driver's seat, so that both the platform and the seat can be swivelled about the column. The front axle is suspended from the chassis by a sprung cradle 12. The steering is transmitted from the arm 7 to the track rods by a link and a lever 18 pivoted to the axle. The control pedals A, B and C engage either of two sets of studs projecting from a control box beneath the platform 8 and cross-coupled by levers pivoted within the box. (*Accepted December* 18, 1939.)

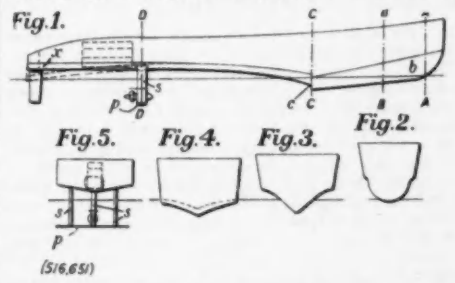
516,774. Radiator Water-Level Indicator. Associated Equipment Company, Limited, of Southall, G. J. Rackham, of Bourne End, and D. A. McCallum, of Wembley. (2 *Figs.*) July 6, 1938.—The invention is an indicator for showing the level of the water in the radiator of a motor vehicle. The filling opening of the radiator tank is closed by a hollow cap 13. An oblong float 18 is mounted within the tank between baffles 9 and is pivoted to the



rear wall of the tank. The indicator is carried on the cap and consists of a sliding rod 22 with a boss 23 which is moved by the float 18. To protect the float 18 from a filling funnel inserted into the filling opening of the tank, a tubular guard 24 is secured to a bush screwed into the filling opening. The coupling between the float 18 and the indicator rod 22 is a U-shaped arm 26 which reaches under the cylindrical guard 24. The cap 13 has a crown 29 supported on pillars between which the boss can be seen. The boss is guided partly in the cap and partly in a tubular shield 33 screwed into the cap. (*Accepted January* 11, 1940.)

SHIPS AND NAUTICAL APPLIANCES.

516,651. Speed-Boat Hull. William Denny and Brothers, Limited, of Dumbarton, and J. F. Allan, of Dumbarton. (13 *Figs.*) July 4, 1938.—The invention is a speed-boat hull of the kind in which an aft main plane remains totally submerged when the boat is in motion and maintains the aft part of the hull clear of the surface of the water. Figs. 2, 3, 4 and 5 show the shapes of the sections of the hull at AA, BB, CC, DD, of Fig. 1, respectively. The main plane *p* supports 70 to 80 per cent. of the weight of the boat when travelling at top speed. Under these conditions it works on that part of the lift curve which lies just below the angle of incidence for maximum lift-drag ratio, or about 3 to 4 deg. from the no-lift angle and has a high aspect ratio, in some cases up to 25. The number of struts *s* is the minimum compatible with strength and they are placed to give the least possible bending moment in the main plane *p*. Their length is greater than the maximum wave height so that the largest waves in which the boat has to run at speed will not cause air to penetrate to the plane. The main-plane angle of incidence is variable within a certain range, the hinged plane being divided



port and starboard and placed under differential control so that the angle of incidence can be varied jointly or separately. This facilitates high-speed turning and assists lateral stability at speed. The remaining weight of the vessel is supported by a short planing bottom *b*, ending in a step *c*. The planing bottom *b* is of V-section below the chine (Fig. 3) to give directional stability easy riding in waves and a lateral stabilising force when the vessel rolls. The keel line to the forefoot remains in the water at speed, so that as the stern rises off the water the forward part of the bow drops slightly. The centre of pressure of the planing bottom *b* will, therefore, move forward and thus increase the load on the main plane *p*, tending to promote longitudinal stability. The after portion of the hull ends in a flat planing bottom *x*. A screw propeller is supported from the centre main-plane strut (Fig. 5). Thin sharp-edged rudders at the after end of the hull reach down approximately to the depth of the main plane. With this construction, as the hull gains speed, the bow rises first and so increases the main-plane incidence. As the speed further increases, the main part of the hull rises under the influence of the main-plane lift and pivots approximately about the forward support. (*Accepted January* 8, 1940.)